ANALYSIS OF THE EFFECTS OF ONLINE HOMEWORK ON THE ACHIEVEMENT, PERSISTENCE, AND ATTITUDE OF DEVELOPMENTAL MATHEMATICS STUDENTS

By

Amy E. Barnsley

RECOMMENDED:

Gary Jacobsen

Dr. Gary Jacobsen

Jill Faudree

Dr. Jill Faudree

Anthony Rickard

Dr. Anthony Rickard

Ute Kaden

Dr. Ute Kaden, Advisory Committee Chair

Philip P. Patterson

Dr. Philip Patterson
Chair, School of Education Graduate Program

APPROVED:

Allan Morotti

Dr. Allan Morotti
Dean, School of Education

John P. Eichelberger

Dr. John Eichelberger
Dean of the Graduate School

4/25/14

Date

ANALYSIS OF THE EFFECTS OF ONLINE HOMEWORK ON THE ACHIEVEMENT, PERSISTENCE, AND ATTITUDE OF DEVELOPMENTAL MATHEMATICS STUDENTS

A

DISSERTATION

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree

of

DOCTOR OF PHILOSOPHY

By

Amy Elizabeth Barnsley, BS, MAT

Fairbanks, Alaska

May 2014

Abstract

This dissertation summarizes a study of the use of online homework with developmental mathematics students at the University of Alaska Fairbanks. To address the problem of high failure rates in developmental mathematics courses this study investigated the relationship between online homework and academic achievement, persistence, and attitude. Special focus was placed on non-traditional and Alaska Native students.

A matched pair experimental design was employed. The independent variable was homework type and the dependent variables were achievement, persistence, and attitude. Nineteen sections of developmental mathematics, six instructors, and 423 student participants were involved.

The main effect of homework type was not statistically significant to any of the dependent variables. However, the effect of the interaction between homework type and course level was significant ($p = 0.005$). Upon further analysis it was found that one of the four levels (beginning algebra) had significantly higher post-test scores when online homework was assigned. The interaction effects of homework type/ Native status and homework type/ non-traditional status were not statistically significant on any of the dependent variables.

Also, results from homework questionnaires were compared. In general, students rated paper homework slightly higher than online homework. Instructors rated online homework higher than students did. Non-traditional students scored paper homework higher than online homework.

The conclusion of this study is that while students have a slightly more favorable attitude toward paper homework, online homework in conjunction with graded paper quizzes and face-to-face instruction does not have a negative effect on achievement or persistence.

Table of Contents

Page

Page

Page

List of Figures

List of Tables

List of Appendices

Acknowledgments

Thank you to Jane Weber, University of Alaska Fairbanks, Department of Developmental Education for encouraging and allowing me to conduct this research with our students and faculty. Thank you to Dr. Yuhua Su, PhD in Statistics from North Carolina State University, for her assistance with the statistical analysis. I am forever indebted to my mom, SJ Barnsley, for her editing skills and knowledge of Word and PowerPoint. This journey would not have been started or completed without the encouragement of Ute Kaden.

Chapter 1 Introduction

For over 25 years improving mathematics education has been a major issue in the United States. In 1989 the National Council for Teachers of Mathematics produced the first complete version of Curriculum and Evaluation Standards. The need for high quality mathematics education is greater than ever. The United States must rally for excellence in mathematics education for *all* students. Knowledge and skills in mathematics are critical for strategically positioning the United States in solving global economic and environmental dilemmas. Students must be able to rely on skills developed from learning mathematics to analyze problems, imagine solutions, and bring productive new ideas into being (Carnegie Corporation, 2009; AMATYC, 2010).

To fulfill the need for future problem solvers, all students need to be given the opportunity to develop these skills. However, students do not arrive at institutions of higher education with equal readiness for college level mathematics (Mulvey, 2009; ACT, 2011). The National Center for Educational Statistics suggests up to 30 percent of students entering colleges need to take developmental coursework (Provasnik & Planty, 2008).

Minorities are especially struggling with preparedness (ACT, 2011; Burnett & Lampert, 2011; Hallett & Venegas, 2011). Native Americans, which include Alaska Natives, are about half as likely as White students to be ready for college level mathematics (ACT, 2005). Rural communities and small schools are less likely to offer more rigorous, upper level math classes (Weiss, Carolan & Baker-Smith, 2010). This problem is especially relevant in Alaska, since many Alaska Native students graduate from rural schools.

Non-traditional students are also more likely to be underprepared (Mulvey, 2009). Non-traditional students make up 25 to 31 percent of undergraduates (NCES, 2012b). This large group has an abundance of talent that can be developed.

Developmental education strives to fill the gaps in mathematical competency and provide opportunity for all students. The mission of developmental education is to help students obtain the necessary academic and affective skills needed to gain entry to college level mathematics (Boylan, 2009; Armington, 2002).

Statement of Problem

Developmental education provides opportunity for students who would otherwise not be able to attend higher education. Community colleges experience lower completion rates than four year-institutions (Provasnik & Planty, 2008). In 2006, 39 percent of degree or certificate-seeking students who enrolled in community college in 2003-2004 left without completing a degree or certificate from either the same school or another school (Provasnik & Planty, 2008). The percent of students who left four-year institutions without completing a degree was only 17 percent.

Students who take developmental coursework are even less likely to finish their postsecondary education. Fewer than half of students who are referred to developmental coursework at community colleges actually complete the entire sequence to which they are referred (Baily, Jeong & Cho, 2009). Placing into a developmental course would have the obvious effect of lengthening the time to completion, and time to completion is correlated with completion rates (Clery, 2011). When students take and complete the developmental course sequence, there is a 50 to 55 percent chance they will complete the subsequent college level course (Baily et al., 2009).

Developmental education is targeted to improve both the academic and affective skills of students. Academic skills are the specified student learning outcomes for each course. Affective skills include positive attitudes, the abilities to work cooperatively, self-assess, manage time, persevere, and have self-confidence. Affective skills can be taught and these skills can mature.

Students' academic and affective skills can be influenced by pedagogical decisions on homework. Homework itself can be suggested or required, graded or not, assigned as online work or in paper and pencil format. These pedagogical decisions impact students' ability to pass mathematics classes and generally gain the student skills needed to succeed in higher education.

The problem addressed in the current study is the high percentage of students who do not pass developmental mathematics classes. To address the high failure rates the current study investigates the relationship between online mathematics homework and academic achievement, persistence, and attitude.

Proportionate to the general population, non-traditional and minority students, including Alaska Natives, are more likely to enroll in developmental mathematics courses (Mulvey, 2009; Guillory, 2009). Additional analysis is done on these populations.

Purpose of the Study

The purpose of the study is to analyze the effects of online homework on achievement, persistence, and attitude, with special focus on non-traditional and Alaska Native students.

Research Questions

This study examines the following research questions:

1. To what extent does online homework affect the achievement of students enrolled in developmental mathematics courses, as measured by a post-test, final course grade, and pass rates?

2. To what extent does online homework affect the persistence of students enrolled in developmental mathematics courses, as measured by attendance and withdrawal rates?

3. To what extent does online homework affect the attitudes of students enrolled in developmental mathematics courses, as measured with the Fennema-Sherman Mathematical Confidence and Mathematical Usefulness Scales, and homework questionnaires?

Summary of Methodology

The study used an experimental research design. Ten sections of developmental mathematics courses used online homework and served as the treatment group. Nine control sections of developmental mathematics used paper homework. The independent variable was homework type. The dependent variables were achievement, persistence, and attitude.

To ensure confidentiality, all student participants were assigned a random confidential identifying number. The number was applied to the student characteristic survey, pre-test, pre- and post-attitude surveys, and to the homework questionnaire.

Analysis of variance, multiple logistic regression, and proportional odds modeling were used to determine the relationship between the independent variable (homework type), and the dependent variables (achievement, persistence, and attitude). Three measures of achievement were used. Achievement was measured post- test, final course grade, and pass rates. Two measures of persistence were used: attendance rates and withdrawal rates. Three measures of attitude were used: Fennema-Sherman Usefulness Scale, Fennema-Sherman Confidence Scale, and homework questionnaires. The following covariates were considered: pre-test, course level, instructor, number of times class met per week, time of day, Alaska Native status, and non-traditional status.

This study also administered a homework questionnaire. Responses were numerical (scored 1-5) and quantitative analysis methods were employed. Responses were compared using the Wilcoxon Rank-Sum Test.

Theoretical Framework

The study is founded on theoretical underpinnings of constructivism, the progressive ideas of John Dewey, adult learning theory of Knowles, and cognitive theory of multimedia learning. One of the core ideas of constructivism is that knowledge is actively constructed by the learner, not passively received from the outside (Sjøberg, 2007). Learning is something done by the learner, not something that is imposed on the learner. Dewey felt genuine learning came from active participation in learning (as cited in Ehrlich, 1998). Sense making does not happen during the lecture. Sense making and learning occur away from the classroom in the home setting. Active participation in homework is where mathematics learning takes place, and learning experiences should center on the individual interests and the needs of students. Dewey encouraged education to shift from teaching to learning and to shift in the role of faculty member from teacher to coach (Ehrlich, 1998).

Cobb, Yackel and Wood (1992) argued that the theoretical position of constructivism does not mean that students learn spontaneously and without intervention. They argue that mathematical knowing has a social as well as a cognitive aspect. The social aspect includes the instructor. The pedagogical decisions that teachers make do have on influence on learning. These concepts form the foundation for this research. This researcher believes that the opportunity to learn is created in part by the instructor.

Malcolm Knowles defined andragogy in 1980 as the art and science of helping adults learn (Merriam, 2001). This is equivalent to the North American understanding of adult education or adult learning theory. The five assumptions underlying andragogy describe the adult learner as someone who (1) has an independent self-concept and who can direct his or her own learning, (2) has accumulated a reservoir of life experiences that is a rich resource for learning, (3) has learning needs closely related to changing social roles, (4) is problem-centered and interested in immediate application of knowledge, and

(5) is motivated to learn by internal rather than external factors (p. 5).

Adult learners should feel respected. The relationship between teacher and student is of joint inquirers. The current study holds these assumptions about adult learners. Merriam (2001) reviews literature on adult learning theory that analyzes the importance of emotions and affective dimensions of adult learning. Adult learning theory advocates considering the needs and wants of the adult students. Adult learning theory is part of the author's theoretical framework. In the current study student opinion and attitude are included factors because they are core to teaching adults.

Three basic assumptions underlie cognitive theory of multimedia learning (Sorden, 2013). First, there are dual channels of information processing. Humans possess separate channels for processing visual and auditory information. Second, humans are limited in the amount of information that can be processed in each channel at one time. Third, humans engage in active learning by paying attention to incoming information, organizing incoming information, and integrating incoming information with other knowledge. Cognitive theory is the foundation of instructional design that should guide how, what, and when information is presented based on the students' response pattern. Online homework addresses these assumptions. Online homework programs can present information visually and auditorily. Students can regulate the amount of information processed by starting, stopping, and pausing the information flow. This researcher accepts the assumptions and theory of multimedia learning. With this theoretical framework the current study seeks to analyze the effects of online homework.

Definition of Terms

Online homework: Homework that is done exclusively online. Online homework can be completed from any computer that has internet access. Instructors select the type and number of problems and set deadlines for each assignment. The online homework program grades homework automatically. An unlimited number of reattempts, up to the deadline, are allowed. The overall homework average for online homework is used toward the calculation of the final course grade.

Paper homework: Homework that is done exclusively with paper and pencil. Instructors select problems from a required textbook, assign the problems to be due by set deadlines and grade the homework. The overall homework average for paper homework is used toward the calculation of the final course grade.

Developmental education: any courses or services provided for the purpose of helping underprepared college students attain their academic goals (Boylan, 2002). Developmental education is different from remedial education. Remedial education refers to the level of coursework, but developmental education has a broader definition and goal. Developmental education seeks to develop affective attributes as well as academic preparedness (Boylan, 2011). Developmental education uses learning theory and developmental psychology to support its focus on the growth of each learner (NADE, 2012).

Non-traditional student: The National Center for Education Statistics website (2012) list the following characteristics which describe a non-traditional student. Students are considered “moderately non-traditional” if they have two or more of the following traits:

- Delays enrollment (does not enter postsecondary education in the same calendar year that he or she finished high school)
- Attends part time for at least part of the academic year
- Works full time (35 hours or more per week) while enrolled
- Is considered financially independent for purposes of determining eligibility for financial aid
- Has dependents other than a spouse (usually children, but sometimes others)
- Is a single parent (either not married or married but separated and has dependents)
- Does not have a high school diploma (completed high school with a GED or other high school completion certificate or did not finish high school).

Alaska Native: For this study students self reported Alaska Native status.

Attitude: To narrowly focus this broad category, attitude was measured as mathematical usefulness and confidence. Mathematical usefulness is how useful a student finds mathematics. Mathematical confidence is how confident a student feels towards his or her own mathematical ability.

Significance of the Study

The study was designed to add to the existing body of knowledge and understanding of the use of online homework in developmental mathematics courses in the college setting. The results of this study will be significant to post-secondary mathematics education. The findings of this study will be shared with the stakeholders at the University of Alaska Fairbanks (e.g. students, faculty, administration, and advisors). Recommendations resulting from the study may impact future decisions regarding the use of online homework in developmental mathematics courses, and advising of Alaska Native and non-traditional students. This research may potentially have implications for the use of online homework in other levels of mathematics and in other subjects.

Summary

Developmental mathematics instructors help students obtain the academic and affective skills needed to gain entry to college level mathematics. A constructivist point of view is assumed. A core belief of constructivism is that knowledge is actively constructed by the learner, not passively received from the outside. In this context, it is assumed that homework is one way that learners construct knowledge on their own, and that homework has a positive effect on achievement.

The problem addressed in this study is the high number of students who do not pass their developmental mathematics classes. To address this problem, this study investigates the relationship between online homework and student achievement, persistence, and attitudes. Since non-traditional students and minority students, such as Alaska Natives, are overrepresented in developmental education (Mulvey, 2009) additional analysis is done on these groups.

An experimental research design and quantitative analysis were used to study this problem. The control group was given paper homework and the experimental group was given online homework. Quantitative analysis of achievement, persistence, and attitude was done using analysis of variance, multiple logistic regression, and proportional odds modeling. Statistical analysis on the student and instructor questionnaire was done with Wilcoxon Rank-Sum Test.

This dissertation is organized into five chapters. The first chapter introduced the topic, described the need for the study, presented a statement of the problem, explained the purpose of the study, postulated the research questions, summarized the methodology, provided the theoretical framework and definitions of terms, and outlined the significance of the study. Chapter Two provides a review of the relevant literature. Chapter Three describes the methodology, including the research design, participants, instrumentation, data collection procedures, data analysis procedures, and limitations of the study. Chapter Four presents the results obtained in tabular, graphic, and narrative form. The last chapter, Chapter Five, presents conclusions, discussion, and recommendations for further study.

Chapter 2 Literature Review

Introduction

The purpose of the study is to analyze the effects of online homework on achievement, persistence, and attitude, with special focus on non-traditional and Alaska Native students.

This chapter will review existing literature as it pertains to the elements of the study. It will include a summary of research on mathematics homework, developmental education, and current recommendations. It includes an examination of research on Alaska Native and non-traditional students in higher education. Lastly, a thorough summary of recent research on the use online homework in post-secondary mathematics is presented.

Mathematics Homework

Homework-achievement research has more often focused on K-12 education than at the college level. However, some of the issues are applicable to the college level setting and should be considered having implications for college mathematics. Meta-analysis done by Cooper, Jorgianne and Patall (2006) has shown there is a positive correlation between homework and achievement. Their analysis revealed time on homework is positively associated with class grade, and that homework has a more positive effect on grades 7-12 than it does on younger students. They suggest this is due to the maturity of study skills; thus implying there might be an even greater effect for college students. Weems (1998) found more students enrolled in developmental intermediate algebra classes earned A's when homework was collected. Ramdass & Zimmerman (2011) studied how homework can influence the development of self-regulation skills, and discussed how requiring homework influences far more than achievement.

Motivation to do homework comes from a balance of both the desire to succeed and the desire to avoid failure (Carifio & Carey, 2009). Grading practices should reflect this. If too much of the grade is dependent on only a few scores, students feel a course is hopeless if they have one low score. Grading homework can "keep the hope alive". The policy of "keeping hope alive" is recommended by several researchers (Carifio & Carey, 2009; Cox, 2011). In contrast, Elikai and Schuhmann (2010) found that with upper division accounting students, a stricter grading score (below 65 percent earned an F) had a significant effect on achievement. A stricter grading schema was correlated with higher achievement. The authors suggested the maturity level of the students might have had a confounding effect on the results. They wondered if the results may have been different if the study was done with less mature students.

Contradictory results are suggested in research on homework. Trautwein, Schnyder, Niggli, Neumann and Ludtke (2009) called the contradictions found in homework research the "chameleon effect". Confounding variables such as prior knowledge and socio-economic factors affect the outcomes of homework-achievement studies. They recommend that homework-achievement research should include more complicated models including concomitant factors such as sociological issues, prior achievement, and affective factors such as homework effort and homework emotions.

Although their study was not done with college students, the recommendations clearly apply to research on college level mathematics.

Flores and Roberts (2008) concluded that de-emphasizing homework with low income (mostly Latino) high school students was a productive strategy for raising student achievement in algebra. These findings are important to consider when doing research on best practices with minority students.

George (2010) claims it is not ethical to offer individual interventions in developmental mathematics. Motivation based regimens, such as graded homework, should be implemented only if the expectations and grading are applied to the whole class. He cautions against “caring” for individual students, as it could lead to an expectation of being “passed along”, regardless of the exit criteria stated in the syllabus. This recommendation seems inconsistent with the recommendations of National Center for Developmental Education (NADE, 2012), who claim the role of developmental education is to consider both the affective and academic needs of students.

Gutarts and Bains (2010) were surprised to find no significant difference in college calculus course grades when homework was mandatory versus when homework was optional. Upon further analysis, they conjectured that the feedback was the component that most affected grades. Feedback took the forms of solution sets, graded homework, and examples covered in class. They cited a study showing that partial grading of homework did not have an effect on performance.

Hong, Wan and Peng (2011) researched student and teacher perceptions of homework. A background assumption for their research was that homework is important for student learning and achievement. They cited prior research (Hong, Peng & Rowell, 2009) that found students' view of the value of homework and their personal effort are positively related to achievement. Thus they wanted to better understand how students perceived themselves and compare that to how teachers perceive the students. They found that students' self-ratings of homework behaviors were more negative than teacher ratings. This finding could be interpreted as students being more critical of themselves in viewing their homework behaviors. Hong, Wan and Peng claimed that teachers that have a good understanding of students' homework experiences could improve the quality and relevance of homework, thus ultimately improving achievement.

Most researchers agree that homework does have a positive impact on student success. In an effort to improve the positive impact, homework modality is a common current research topic. Technology has made available new models for delivering mathematics instruction, including homework formats. Burch and Kuo (2010) addressed the question of whether online homework facilitates understanding and retention of material better than traditional paper-and-pencil homework in college algebra courses. They found that midterm exam scores and retention rates were statistically higher in sections with online homework, but final exam scores were not significantly greater. They attributed the positive impact to the fact that online homework provided extensive repetition with feedback between re-attempts. Lenz (2010) supported these conclusions. She studied freshman level credit-bearing mathematics and the effects of web-based homework. She also found no significant difference in student outcomes, as measured by a modified final course grade, that is a grade calculated without homework. However, she did find statistically more positive student and teacher satisfaction with web-based homework.

Taylor (2008) studied the effect of a computerized algebra program on achievement in developmental mathematics courses. She found a positive relationship between achievement and computerized homework. When studying first semester college calculus students, Zerr (2007) also found significant qualitative evidence that supports the hypothesis that online homework improved student learning.

The current study follows the assumption that homework has a positive impact on student learning. It seeks to determine if some types of homework have a greater impact than others, and if some subpopulations do better with one type of homework over another.

Developmental Education

Developmental education was historically known as remedial education. As the field developed, this term became outdated because it didn't encompass the big picture. It is true that one distinguishing feature of developmental students is that they are underprepared for college level course work. But the word remediation implies that the student is just missing academic skills, and with a little instruction they will be college ready. But in truth, this group is often missing more than academic skills. They can be in need of many or all of the affective skills mentioned previously. "Developmental education is the integration of academic courses and support services guided by the principles of adult learning. Remediation is a sub-component of developmental education involving the provision of coursework addressing pre-college material" (National Center for Developmental Education, 2013).

According to the National Center for Education Statistics (Provasnik & Planty, 2008) twenty to thirty percent of students entering two or four-year colleges need to take developmental coursework. Baily, Jeong and Cho (2009) reported 58 percent of community college students took at least one remedial course. It is important to keep in mind, that the words "remedial" and "developmental" are often used interchangeably. However, the National Center for Education Statistics study used the word "remedial". Therefore, it is possible students would have responded differently if they were asked about "developmental education coursework". For this reason, it is hard to compare estimates of developmental education course taking over time.

Most estimates indicate that the number of students taking developmental coursework is increasing, and is likely to be at least one third of all college students. In addition, the needs of the students are increasingly diverse. "Given the large increases in postsecondary student enrollment and the open admissions policies offered by many institutions, student populations have become increasingly diverse and many new students (especially nontraditional students) are entering college each year" (p. 11, Provasnik & Planty, 2008). The role of developmental education within postsecondary institutions is growing.

Research in developmental education falls into two large categories. One category of research examines *why* there are so many students who need developmental education. The other category examines *how* developmental education is implemented, and seeks to refine teaching methods. The current study is motivated by the need for continuous improvement and refinement of effective instructional practices, and thus falls into the second category.

Developmental education aims to improve student's affective skills. Student opinions and affective skills are important factors in student success. Kendricks and Arment (2011) found that underrepresented minorities in science, math and engineering programs performed better and had higher retention rates when participating in a program that addressed their affective needs. Pitre and Pitre (2009) found similar results with economically disadvantaged and underrepresented ethnic background students involved in TRIO programs. The TRIO programs are federal outreach programs designed to identify and provide services for individuals from disadvantaged backgrounds. Studies have found significant correlation between student attitude and passing rates for developmental math students (Armington, 2002). Teaching practices aimed at facilitating student growth and independence in academic, social, and personal aspects have been shown to be successful with developmental students (Michael, Dickson, Ryan & Koefer, 2010).

Mulvey (2009) examined the backgrounds and characteristics of developmental students. First generation, adults returning to school, low socio-economic background, learning disabled, and minority students are over represented in developmental education. Mulvey (2009) cited a study done by Saxon and Boylan in 2000 that indicated at four-year colleges the mean age was 19 years old, but at two-year colleges the mean age was 23. At two-year colleges 51 percent of students were financially independent and one third of the students were not white. The current study included students from a four-year college with a median age of 25, and a student population that is 19.7 percent Alaskan Native/ American Indian. This university has an lenient admissions policy.

Proportionate to the general population non-traditional and minority students, including Alaska Native, are more likely to enroll in developmental mathematics courses (Mulvey, 2009; Guillory, 2009). In the current study these two special populations comprised a significant number of students.

Alaska Natives

Education in rural Alaska has many challenges. There are many theories about why K-12 schooling has not always been effective at meeting the needs of Alaska Native students. Staffing very small schools with teachers strong in content knowledge can be difficult (Flores, 2007). Rural schools are less likely to offer challenging coursework, such as AP classes. Rural schools attract less experienced teachers, and have higher teacher turnover rates (Roehl, 2010). Cultural differences exist between Non-native teachers and Native students.

Constructivism would argue that Alaska Native students would benefit from constructing knowledge within the context of Alaska Native culture. But that is difficult given that mathematics historically comes from a western paradigm. Alaska Native students are a disadvantaged group when they arrive at college. There is a very real need to research what works best with Alaska Native college students.

In national studies Alaska Natives are included in the category American Indian, (Alliance for Education, 2008). An examination of national statistics on the under-preparedness of minorities sheds light on the under-preparedness of Alaska Natives. In 2005, ACT reported Native Americans are about half as likely as White students to be ready for college level mathematics (ACT, 2005). The percent of 2004 ACT tested high school graduates that meet the college algebra benchmark (ACT's definition of college-ready) was 46 percent for White students and 24 percent for American Indian. Then in 2011 ACT reported that while 54 percent of White students met College Readiness Benchmark in mathematics 25 percent of American Indian students met the Benchmark (ACT, 2011). While White students are making significant gains in preparedness, American Indians were not. ACT also reported, by ethnicity, the percent of students who completed at least three years of mathematics in high school. Access and preparation of minority students is consistently lower. An average of 68 percent of African American, American Indian and Hispanic students complete the core curriculum, while 76 percent of Whites and 81 percent of Asians completed the core (ACT, 2011). The composite ACT score for White students remained at 21.8 between 2000 and 2004, while Native American students went from 19.0 down to 18.8 (ACT, 2005).

There is much agreement (Flores, 2007; Weiss et al., 2010; Davis & Palmer, 2010; ACT, 2011; Burnett & Lampert, 2011, Hallett & Venegas, 2011) on the fact that minority students not only have a gap in achievement, but a gap in opportunity. Flores (2007) summarizes three opportunity gaps: access to experienced and qualified teachers, opportunity to benefit from high expectations of achievement, and opportunities to receive equitable per student funding. The National Council for Teachers of Mathematics (NCTM, 2012) posits that the achievement gap that minorities experience is a result of differential instructional opportunities. The solutions suggested include providing access to high-quality teachers and high expectations for mathematical achievement.

Oates (2009) evaluated prominent reasons for the black/ white performance gap. He sorted the prominent reasons into two categories. The first category was defined as what students “bring to school”. This category included academic engagement, cultural capital, and social capital as explanations for the performance gap. The second category was defined as “what happens to” students when they get to school. This category included quality of education provided and race-contingent treatment received as explanations for the performance gap. He concluded that the performance gap was more affected by “what happens to” students when they get to high school, rather than what students “bring to school”.

Weiss, Carolan, Baker-Smith (2010) researched the relationship between school size and mathematics achievement. They determined small school populations “tend to exacerbate already extant disadvantages among adolescents, particularly with regard to race” (p. 173). They hypothesized the most beneficial school size is around 600 students. A disproportionate number of minority students are enrolled in very large urban schools and very small rural schools. Minorities, including Alaska Natives, are not being given the same advantages as White students. Given the well-documented problems of performance, opportunity gaps, and the recommendation of researchers and professional organizations it is critical to include special analysis of Alaska Native students in the current study and to determine if certain instructional practices are more or less beneficial for this population.

The US Census Bureau (Lumina Foundation, 2012) reports for the 2008-2010 census that at the national level, 43 percent of White students between the ages of 25 and 64 have attained a college degree, while only 23 percent of Native Americans in the same age group had. This figure is not specific to Alaska Natives, but does include Alaska Natives. The degree attainment of this group for the state of Alaska is even more striking. The statistic for White students remains 43 percent in the state of Alaska, while the statistic for Native Americans drops to just 12 percent (Lumina Foundation, 2013).

According to the National Center for Educational Statistics (NCES, 2012a) six-year graduation rates for first-time, full-time students who sought a bachelor's degree in fall 2004 varied by race/ ethnicity. White students had a 62 percent graduation rate while American Indian/ Alaska Native students had a 39 percent graduation rate.

Erickson and Hirshberg (2008) reported that at the University of Alaska Anchorage 67.6 percent of first-time, full-time students who started in 2000 continued to their second year, while only 51.6 percent of Alaska Natives continued. The six-year graduation rate for Alaska Natives was 10.9 percent, while all students graduated at a rate of 24.5 percent.

Wolfle (2012) studied the success and persistence of developmental mathematics students based on age (defined as 23+, or younger than 23) and ethnicity (defined as White or non-White). Wolfle found no significant interaction effects between developmental status and age or developmental status and ethnicity on either the success of a student in their first college-level mathematics course or on the students' persistence to a second year of college.

The number of underrepresented minorities earning college degrees in STEM fields (science, technology, engineering and mathematics) are significantly lower than White and Asian students (White, Altschuld & Lee, 2006). In this paper the authors identified certain components of culture that contribute to retention in STEM majors. Specifically, they found "comfortable and confident feelings" influence minority retention. Given this finding, the current study includes a measure of confidence, with separate analysis on Alaska Native students.

These studies indicate the need to improve postsecondary education for Alaska Native students. In an effort to make such improvements, the current study explores the impact of type of homework, attitude, and opinion of Alaska Native students' success and persistence in developmental math.

Non-Traditional Students

Non-traditional students, who make up 25 to 31 percent of undergraduates nationwide, tend to be older, financially independent students who attend college part time (NCES, 2012b). Barbara Bonham, with the National Center for Developmental Education, stresses the importance of understanding non-traditional students. Educators need to work with non-cognitive, or affective factors, as well as cognitive factors in helping non-traditional students to be successful (Berg, 2005; Campbell & Brigman, 2005). Developmental teachers should strive to have non-traditional students feel safe and have a sense of belonging. In keeping with these recommendations, the current study explores the opinions and attitudes of non-traditional students.

Current Recommendations

The National Center for Developmental Education and the Continuous Quality Improvement Network (a consortium of 35 higher education institutions) combined relevant findings from major studies to summarize the best practices for developmental education. The end product was the book *What Works: Research-Based Best Practices in Developmental Education* (Boylan, 2002). Thirteen specific and practical suggestions are provided in the section on best instructional practices. Five of these instructional practices are relevant to the current study.

The first recommendation is educators should accommodate diversity through varied instructional methods. No single instructional method will work for all students. Developmental students are the most diverse group in contemporary higher education. Their learning styles and non-cognitive needs are much more diverse than the traditional college students. Therefore, it is appropriate to offer a range of instructional methods. Given the diversity, it is apt to offer alternatives to the traditional lecture and paper homework model. Specifically, the use of computer-based instruction can be a model that might work better with these students. The current study explores the effectiveness of online homework with two subgroups: non-traditional and Alaska Native students. Results of prior research are varied. Some results are favorable for online homework (Burch & Kuo, 2010; Taylor, 2008; Zerr, 2007), while other show no significant difference (Lenz, 2010; Kodippili & Senaratne, 2008; Jacobson, 2006). This might be due to the wide variability in developmental education students. The current study attempts to dissect this issue: who benefits from online homework?

The second recommendation from Boylan's book is the use of technology in moderation. Boylan cited a 1992 study by himself, Bonham, Claxton and Bliss that claimed when computer technology was the only means of instruction, developmental students performed poorly (as cited in Boylan, 2002). They concluded that technology should not be used as the only means of instruction. The current study follows this recommendation. This study involves traditional lecture classes with and without web-based homework. However, it is important to note that more than twenty years have gone by since this 1992 study was performed. Vast improvements have occurred in e-Learning classes, educational technology, and computer assisted learning. Not all researchers agree with the recommendation to limit the use of technology. Potocka (2010) claims entirely online developmental math classes can have the same pass rates as traditional face-to-face classes. Biswas (2007) reported "promising" results from self-paced, modularized, computer aided developmental math classes at two community colleges. Other current studies have shown that a blended format (computer and in-person instruction) is better than courses with only computer instruction (Kendricks, 2011; Zerr, 2007).

The third relevant recommendation from Boylan (2002) is to provide frequent and timely feedback. This is probably the number one benefit of online homework. Students are given immediate feedback, and the opportunity for re-attempt. The feedback is often more than just "right- or- wrong" feedback. Meaningful feedback, whether given electronically or with paper-and-pencil, benefits students. Timely, non-threatening feedback offered by online homework eases the anxiety that non-traditional students face (Li & Edmonds, 2005). Gutarts and Bains (2010) studied college calculus students and the impact of collected, graded homework versus recommended, non-collected homework which included graded quizzes. They found no significant difference in final exam scores, but reasoned that was because both groups where given graded feedback, one in the form of quizzes and the other in the form of homework. In both the control and the experimental groups of the current study students were given frequent and timely feedback.

The fourth recommendation is the use of mastery learning, where students demonstrate mastery over material before moving to the next lesson. Sullivan (2005) found that mastery learning has a positive effect on learning disabled students in developmental college mathematics. "Mastery learning typically provides some sort of instructional laboratory where students can see clarification of material presented in the classroom" (Boylan, 2002, p. 87). Online homework provides students with out of class instructional videos and examples that can be read and watched an unlimited number of times. Repeated attempts on homework problems encourage mastery of material. In the current study, online homework was used as a mastery learning tool. It provided students' unlimited retakes of similar problems (not the exact same problem) and the opportunity for success. This allowed students to put more individual time on learning and strengthening their skills.

The last recommendation is that instructors of developmental education should share instructional practices. The current study analyzes a specific instructional practice, the use of online homework, and its effects on specific subpopulations. This information will be relevant and helpful to other instructors of developmental education.

Technology and Developmental Mathematics

The National Council for Teachers of Mathematics (NCTM, 2000) recommends "technology should be used widely and responsibly, with the goal of enriching students' learning of mathematics" (p.25). Best practice recommendations by the American Mathematical Association of Two-Year Colleges, (AMATYC, 2006) include the use of technology in developmental mathematics programs. Specific recommendations for faculty are to "integrate technology into their teaching of mathematics, use technology tools for assessment that are aligned with instruction, align technology platforms with those familiar to students, required for future courses, and/or necessary in their future careers" (p. 57).

Many developmental students have a history of limited success in learning mathematics. Conventional teaching methods and traditional educational practices can be ineffective for this population. Educators of this group want to provide a different experience for their students. Advances in technology have brought new teaching and learning options to the developmental mathematics classroom.

Kinney and Robertson (2003) reviewed different models for delivering developmental mathematics using technology. The "bolt-on" model combines existing resources such as software for generating problems algorithmically, videos of a teacher presenting each lesson and the textbook. The computer-mediated model of instruction is learner centered. In this model the learner is given flexibility to choose a variety of instructional support resources including interactive multimedia instruction, the instructor, and a printed textbook. This model allows for asynchronous delivery, while the bolt-on method is a synchronous-only model. In both models the instructor is an important component and must still organize the course, provide feedback to students, assess their learning, answer individual questions, and often handle technical issues. In the current study, the bolt-on model was used in the form of traditional lecture with the use of online homework.

Online Mathematics Homework Features, Benefits, and Challenges

There are a variety of online systems with the capacity to deliver homework assignments. There are global course management systems like Blackboard or WebCT. Creating online homework is just one feature of these programs. The instructor creates the questions, solutions, and feedback. There are commercial products like *WebAssign*, *MyMathLab* or *ALEKS (Assessment and Learning in Knowledge Spaces)*. With these programs there is a large bank of problems and the instructors choose which type of problems to assign. Due dates, number of reattempts, the amount and type of assistance (videos, worked examples, step-by-step hints) are some of the settings available to instructors. Internet access is required to do homework. Because it is done online, it does not need to be done in a lab setting. Though universities offer computer labs, most students today do their online homework on their own computers. The feature that is common to these programs is the attempt-feedback-reattempt sequence. Online homework program are infinitely patient. Most have worked examples that students can examine again and again.

Research on the effects of online homework reported both benefits and challenges. Studies have indicated the rapid attempt-feedback-reattempt loop as the reason online homework has a positive impact on student learning (Burch & Kuo 2010; Lenz, 2010; Taylor, 2008; and Zerr, 2007). Timely, non-threatening feedback eases the anxiety that non-traditional students face (Li & Edmonds, 2005). Student performance on specific learning outcomes can be tracked electronically, and this leads to targeted re-teaching. Developmental students often have gaps in their learning. Streamlining the practice of mathematics and narrowing it down to targeted concepts makes the class time, whether online or face-to-face, more effectual (Boylan, 2009). Lenz (2010) and Jacobson (2006) found statistically more positive student and teacher satisfaction with web-based homework.

Challenges for learning with online homework include the availability of high-speed internet access and personal computers. Younger traditional students generally have the comfort level and unfettered access to their computers, while non-traditional students may find it difficult to work on the computer at home (Li & Edmonds, 2005).

Not all students have the same access to the internet. In 2007, 78 percent of American Indian and Alaska Native eighth grade students reported using a computer at home, which was lower than the percentage of any other racial/ ethnic group (DeVoe &

Darling-Churchill, 2008). This could lead to a lower personal computer proficiency rate, which has implications for the current study on the use of online homework.

Getting instructors to effectively implement online homework can be challenging. Too often developmental mathematics classes are taught by adjuncts who are offered little or weak faculty development (Fike & Fike, 2007). There is a marked lack of statistically significant studies on the benefits of using technology. College culture favors traditional instructional formats (Crawley, Fewell, & Sugar, 2009). Instructors use these reasons to not change their teaching methods. Therefore, implementation of innovation can be difficult.

Students benefit from interactions with instructors. Instructors address issues such as availability of resources, social support, and advice on maneuvering through the college system (Kinney & Robertson, 2003). In face-to-face classes, instructors can focus on both conceptual understanding and on procedural fluency. The online component helps to develop the procedural fluency that is often missing for developmental students, freeing up the face-to-face time for helping students with conceptual understanding. Class time can be used to develop contextual learning opportunities, while skills-based learning can be done outside of class time with use of technology.

Review of Research on the Use of Online Homework in Post Secondary Mathematics

Computer assisted mathematics instruction programs have been in use since the 1980s. Research on the use of computers with mathematics education as it existed before the widespread availability of personal computers is not relevant to the current study. Most programs today seek to mimic the attempt-feedback-reattempt loop that is observed when instructors work with students. The widespread use of this type of computer assisted mathematics instruction began in the late 1990s, with such programs as *Interact Math* and *ALEKS*. The quality of the feedback and how the program responds to the user have become more and more sophisticated. For this reason, the review of research on this subject is limited to the last decade. Given rapid changes in educational technology, it would be even more appropriate to limit it to the last five years, but that would be too restrictive.

A comparison of an older program that merely reports if an answer is correct or incorrect to a more modern program that has explanations, support videos, and step-by-step guided help is scarcely appropriate. How an instructor chooses to grade online homework can skew results. Grading schemas affect student motivation. There are many grading schemas for online homework. It can be graded for attempt, correctness, time logged into the online program or completion of all topics. All of which would affect the student's motivation to actively engage in the program. In turn, this would affect online homework's effect on achievement. Consistent with this study, literature was reviewed for face-to-face, college mathematics courses. A review and summary will be presented of sixteen relatively recent studies on the use of computer assisted learning, with an emphasis on the use of online homework.

Pierce and Stacey (2001) sought evidence that the use of computer algebra system, CAS, increased their students' engagement with mathematics, and therefore furthered the learning of mathematics in a college calculus class. Typical of studies more than ten years old, CAS was used only in a whole class setting. Pierce and Stacey utilized action research methods with a small sample size of n=30, consisting of one undergraduate level calculus class taught by both authors.

Both researchers had used the CAS for several years prior to the study. Early use of the program led to informal observations about the potential to increase student engagement in the learning of mathematics. From these informal observations the researchers wanted to explore how CAS influences the learning of mathematics.

Data was collected from surveys, observations, and assessed work. There were six surveys administered throughout the course of one semester. Some of the survey questions were open ended and some used a 5-point Likert scale. Observations were recorded by the teacher-researchers' as soon as possible after class. Observations included significant incidents, memorable student comments, and observations of general classroom activity. Use of the CAS was allowed on exams. The researchers were able to view students' computer screens during the exams and make notes of the students' use of the program. The program also had a reporting feature that allowed further analysis of the use of CAS.

Observations indicated that students were able to use and switch between algebraic and graphical representations of functions, but they seldom used tabular representations. The authors hypothesized why that might be.

The researchers observed that in the computer lab the students worked together more and that student discussions seems to be more focused on the task at hand, than when compared to students discussions when work was given by pen and paper. From the surveys, the researchers were able to document that students perceive the same phenomena, that is: an increase in talking about mathematics in the computer lab setting versus the pencil and paper setting.

One survey sought to collect student perceptions on how CAS affected the students' speed, confidence, and learning of specific concepts. Findings indicated that students preferred paper and paper when demonstrating concepts being recalled from prior knowledge. To demonstrate new concepts students favored the use of technology. The students were observed anthropomorphizing the computers, such as "What does yours think?" The final course evaluation survey indicated that students felt that "CAS might offer fresh hope to students who had previously experienced difficulty with algebra" (p. 42).

This research is included as an example of how the use of research on computer-assisted learning has changed, and as a good example of qualitative research. It is relevant to this author's research interests because it explored student attitudes and perceptions. Pierce and Stacey's research offered detailed qualitative analysis of issues related to use of computers as a learning tool.

Early in the 2000s, the emphasis of research on computer use in mathematics education changed from in-class computer assisted learning to out-of-class assisted learning. The remaining studies presented in this literature review researched the use of online homework in face-to-face college mathematics classes.

Carter (2004) studied 55 freshman enrolled in two basic mathematics classes, one class used online homework and one class used traditional paper homework. Achievement was measured by post-test, with a covariate of pre-test. No significant difference was found in achievement or withdrawal rates. Mathematical attitude was measured with Fennema-Sherman Mathematics Attitude Scale. The confidence and the usefulness scales were analyzed. No significant difference was found between the control and experimental groups. She concluded that the use of online homework is equally as effective as traditional homework alone.

Hagerty and Smith (2005) studied the effectiveness of a web-based software in college algebra class compared to a course taught by traditional means. They had a control group of four sections of college algebra taught with traditional means and an experimental group of four sections that used online homework, resulting in a sample size of n= 251. To control for statistical bias, an attempt was made to have each instructor involved teach at least one section with online homework and one without. However, one instructor in the study taught one traditional homework section, and no online section. To control for student-to-student variability performance was measured as the difference between pre and post-test scores.

Hagerty and Smith considered four influencing factors on performance as measured by difference in pre-test and post-test: student opinion of mathematical ability, student opinion of computers, use of online homework, and traditional versus nontraditional student status. They defined nontraditional students by age of student at the end of the semester, though actual cut off age was not given in the literature. Out of these four factors the only factor found to be statistically significant was the use of online homework.

Long-term skill retention was measured in a subset of the students fourteen months later. Students enrolled in the online homework section performed statistically better than the traditional homework sections. Drop/ withdrawal/ failure (DWF) rate was slightly higher in the online homework section. The authors attributed that to the fact that one of the online homework sections was an evening class, which historically has higher DWF rates. Student opinion of online homework was reported as favorable.

This research indicates that further analysis of influencing factors and long-term skill retention as related to the use of online homework is needed. The definition of non-traditional student is not comprehensive. A more formal definition can be applied to explore this influencing factor.

Butler and Zerr (2005) studied the use of an online course component added to traditional face-to-face freshmen level math classes at two universities. Their study did not have a control group, but looked for correlations between engagement in online assignments and exam scores. They also used surveys to gauge students' attitude towards online assignments. They studied a mechanical puzzle: How does the online homework system work with their students? Why does it work this way? Butler and Zerr reported on the implementation of online homework, student attitudes toward online homework assignments, and evidence that the online assignments were accomplishing their goal of enhancing out-of-class student engagement.

Each researcher implemented an online homework component at their respective universities. The sample size was 381 students at one university and 27 students at the other university. The implementation of the online homework component was slightly different from one another, but both allowed for multiple retake opportunities. Butler and Zerr then looked at how the students performed on exams. They found that exam scores were correlated with online homework scores.

From the survey, the researchers reported that the overall response to the online homework was very positive. To determine how much the online homework assignments were engaging the students, the researchers looked at the percentage of the online homework assignments on which an almost perfect score was earned. They rationalized that a perfect grade was rarely made on a first attempt, therefore near-perfect grades were an indicator of multiple attempts, and hence an indicator of higher engagement in out-of-class student engagement. They determined the online homework did correlate to a higher out-of-class engagement.

This research supports what others have found: that more time spent on homework correlates to better performance on exams. However, since it was not an experimental study they cannot attribute the better performance to the use of online homework. Other researchers have documented positive student attitudes towards online homework. Lenz (2010) and Jacobson (2006) found statistically more positive student and teacher satisfaction with web-based homework.

Jacobson (2006) studied the effectiveness of computer-based homework in an experimental study that included eight sections of prealgebra (n=276) taught at a four-year university. Four instructors participated in the study, each teaching a section with computer-based homework required for part of the semester and a section with paper and pencil homework. Evidence of learning was measured by two out of four exam scores. Student opinion was measured with a survey. Instructors were allowed to decide if homework was graded or not, and it was not consistent throughout the sections involved in the study. Computer based homework was only required for the first half of the semester.

Jacobson found that required computer based homework did not produce higher exam scores. He did find that the instructor factor significantly affected exam scores. This research demonstrates how the lack of control over influencing factors can skew research results. Consistent with Lenz (2010) and Butler and Zerr (2005) students reported positive attitudes towards computer homework.

Zerr (2007) studied online homework with first semester calculus students in a class of 27 students. He created an extensive question bank for use on Blackboard, the university's course management system. After each question, the program gave quality feedback including a full solution and explanations of common mistakes. Immediate feedback and unlimited retakes were designed to improve out of class engagement.

As with other studies, student opinion survey was very positive. To determine if online homework had a positive effect on achievement Zerr took into account prior knowledge as measured by math ACT score. To gauge achievement he divided the group into two subpopulations. The first group contained students who earned fewer than 17 out of 26 perfect scores on the online homework. The second group contained students who earned more than 17 perfect scores. The number 17 was chosen because it kept the groups roughly the same size. Not surprisingly, those students with a greater percentage of perfect online homework score did perform better on exams, 84.43 percent compared to 69.61 percent exam averages. This difference was significant at the 99 percent level. An interesting note is that the first group average Math ACT score of 27.13, and the second group had an average of 28.17, a difference which is not significant even at the 90 percent level. Therefore, it appears that prior mathematical ability can be ruled out as an explanation, and suggests that there is a quantifiable difference in student outcomes based on their success with online homework.

Zerr conducted further analysis to include such variables as age, number of semesters in college, prior calculus experience, number of semesters since last math class, and number of semesters with college math experience. He was able to conclude students in their first semester of college reap the greatest benefit from online homework.

Taylor (2008) studied 93 intermediate algebra students enrolled at two different universities. The experimental group used *ALEKS* online homework, and the control group had traditional homework. Her sample selection method was quite different than other studies. Multiple universities and colleges were asked to participate. Of those that agreed, instructions were given to the chair of the math departments, who were then to distribute them to up to 1500 students. Students voluntarily logged into a web site in September and again in December. Each time participants completed three online assessments: National Achievement First Year Algebra Test, Mathematics Anxiety Rating Scale and Sherman Mathematics Attitude Scale.

In Taylor's research the grading schemas, textbooks, instructors or any other factors were not standardized. The only requirement for the treatment group was the use of the online program *ALEKS,* and the only requirement for the control group was the use of traditional paper homework. This research reflects the reality of using online homework. Using an outside measure of achievement removed the instructor grading variability. The self-selection of participants definitely influences the results, but it does so across the board, since both treatment and control groups were selected in the same manner.

Taylor reported achievement was significantly better in the treatment group. Anxiety level of the experimental group decreased significantly more than the control group. However, there was no statistical difference in changes in mathematics attitude of the two groups.

It is interesting to note that when researchers find no significant difference they cite small sample size as a possible reason, but Taylor had a relatively small sample size (n= 93) and found a statistical difference.

Kodippili and Senaratne (2008) studied academic performance given the use of online homework in college algebra courses. Two instructors participated in the experiment, each teaching one section with online homework and one section with traditional homework. The sample size was small, n=72. In each section, homework was graded and the contribution of homework, exams, final exam and research project to final course grade calculation was uniform in all sections involved in the study.

The average final exam score for the online homework group was 73.7 percent. Traditional paper homework group averaged 67.4 on the final exam. While the difference was notable, it was not statistically significant at a p-value of .0638.

Kodipili and Senaratne (2008) did find a statistically significant difference in success rates as measured by pass rate. The online homework group had a 70 percent pass rate (A, B, C grade) compared to a 49 percent pass rate in the traditional paper homework group. They recommended further study control for extraneous influences such as use of tutoring services, age, and gender.

Smolira (2008) explored student satisfaction with online homework in finance classes. He surveyed 80 students in two undergraduate classes and in one graduate-level finance class. Consistent with previous findings, students reported that the online homework was helpful for learning the material. On average students reported online homework was more valuable than traditional homework. Since this was not an experimental study, the question was referring to students' prior experience with traditional homework. Students reported they spent more time studying because of the online format. The most significant finding of this research was that graduate students reported higher satisfaction with online homework than did the undergraduates. There is a lack of research in how online homework affects different levels (undergraduate versus graduate, or developmental versus college level mathematics).

Stillson and Nag (2009) compared two semesters of remedial algebra (n= 210), both requiring online homework. Their study was observational in nature. They documented benefits of using online homework. The first semester the online program was *ALEKS*, and the second semester the online program was *MathXL.* In addition the textbook changed and an additional requirement of one hour per week in the computer lab was added the second semester. Despite these differences, the authors thought the semesters were comparable. Student opinion surveys were favorable toward online homework both semesters. Stillson and Nag did not measure achievement.

Lenz (2010) researched the use of online homework over a three-year period in a total of seven sections of a required math survey class for non-math/science majors, with a sample size of n=191. The same instructor, using the same grading schema, taught all the sections. Three sections utilized web-based homework, two used paper and pencil homework, and two sections used a combination. The researcher was able to hold many of the variables constant between the three treatments. Lenz did statistical analysis on the following: 1. Attempted homework percentage, 2. Homework average, 3. Modified course grade, 4. Difference between modified course grade and homework. The researcher noted a significant difference in homework average for the online sections. This was due to the fact that online homework allows for immediate feedback and unlimited reattempts, leading to a higher homework average than with paper homework. To accommodate for this Lenz then calculated a modified course grade. The modified course grade was only for the purpose of this study, and was not used for grading purposes. The modified course graded used the exams grade and the final exam grade, and did not include homework. There was no significant difference in the web-based and paper homework sections, but combination homework produced significantly lower modified course grade. Student satisfaction survey indicated that most students (79.17 percent in the web-based and 57.69 percent in the combination sections) were happy with the online homework and would prefer it over paper based homework. Lenz concluded that given no significant *negative* effect on learning outcomes, that instructors and students should enjoy the convenience and positive experience of online homework while achieving similar results as paper homework.

Burch and Kuo (2010) studied the use of online homework versus traditional paper and pencil homework in multiple sections of a College Algebra class. They wanted to determine if "one method would help facilitate the understanding and retention of the material better than the other" (p. 53).

To do this Burch and Kuo collected data over two semesters. The first semester they collected data from sections using paper and pencil homework and the second semester they collected data from sections using online homework. Data was collected from exam scores, homework averages, and final exam scores. This research was strictly quantitative.

The sample size was relatively small, n=52. This was the total number of students from both semesters and all five sections of the class. The study found that students who used the online homework performed statistically better on the exams then those students who used paper and pencil homework. However, there was NOT a significant difference in final exam scores. Paper and pencil homework were better correlated with exam scores. The most important finding was the retention in courses using online homework was 86 percent versus a 58 percent retention rate in the paper and pencil courses.

The small sample size surely contributed to the lack of statistical findings. It would be interesting to explore the correlation of paper and pencil homework with exam scores. Specifically, one benefit of paper and pencil homework is grading that is done by a person, with feedback and grading that may be mimicked in exam grading. In contrast, online homework is graded on correctness only. Did the paper and pencil group receive more meaningful feedback before exams? The retention rate in the online homework sections was noteworthy, and worthy of further exploration.

LaRose (2010) had a large sample size of n=665 for a study of online homework with second semester calculus students. In this study there were three groups. The first group was given paper homework that was neither collected nor graded. The second group was given the same paper problems AND online homework. But like the first group nothing was collected or graded. The third group was given only online homework and it counted for a very small amount of the final course grade. Final course grade was largely determined by performance on three in class exams. Other graded work could include weekly quizzes, team homework, individual paper homework, or individual online homework. By department policy graded work counted very little toward final course grade. "The instructor of each section can adjust up to one-third of his or her students' grades (as determined by their exam scores) up or down by a third of a letter grade" (p. 667). The actual percent that the online homework counted toward the final grade was very small.

LaRose found the graded online homework group spent more time on homework than the other two groups. Time spent on homework was self-reported via three anonymous online surveys administered throughout the semester. For the two online homework groups the data from self- reporting was found to be remarkably consistent with actual time spent with the program (as determined by the reporting component of the program). The graded online group also had a more positive view of homework. The researchers concluded that the grading of homework seemed to be more important than the homework format. Instructors reported being able to spend less time reviewing homework and more time covering new material when online homework was used. No significant difference was found in exam scores.

Brewer and Becker (2010) explored the use of online homework with 145 students in nine college algebra sections. Four sections comprised the treatment group (using online homework), and the remaining five sections made up the control group (paper homework). They included three factors in their analysis: homework type, incoming skill level, and whether or not the student was repeating the class. Incoming skill level was determined by a pre-test. Students self reported their repeat/ non-repeat status. Achievement was measured by the paper and pencil common final exam given to all students.

Brewer and Becker found no significant difference for the treatment and control groups. However, when comparing the subpopulations they did find significant differences. Students with low incoming skill level performed significantly better on the final exam when they used online homework. This subpopulation performed, on average; 10 percent higher on the final exam. No significant difference was found with the high incoming skill level groups. The repeater group did perform 8 percent on higher on the final exam when they used online homework. While this was not statistically significant, the authors felt it was practically significant and worthy of further study. These results have great implication for the current study, demonstrating the need for subgroup analysis.

Cox and Singer (2011) investigated online homework with four sections of college calculus (n=87). They assigned both paper and pencil homework and online homework to all the students. A scatter plot comparing online homework grades to paper and pencil grade revealed an interesting pattern. As would be expected, students who performed low on paper homework also performed low on online homework, and the same was true for high paper/ high online grades. But of the remaining students, only two performed high paper/ low online, the remaining students (approximately 20) performed high on online but poor on paper. The majority of students had an average online homework score 80 or above. By comparison less than 40 percent of students had an average paper homework score of 80 or above. They reported students spent more time working independently on calculus problems. Survey results indicate high student satisfaction with online homework.

Halcrow and Dunnigan (2012) studied the use of online homework in college calculus class (n=232). They had two control sections that were given suggested, ungraded, paper homework. Two experimental sections were given online homework, which counted for ten percent of the final course grade. They found a significant difference in exam scores for one instructor, but not the other. Qualitative analysis did reveal that students felt more motivated to do homework that was graded. Students were favorable toward online homework, and found it motivating that they could succeed by re-attempting online homework. The researchers concluded that the teacher's knowledge, expertise and attitude toward online homework have an impact on the success, or lack of, of online homework.

In summary, none of the studies found online homework to be negatively associated with achievement. About half of the studies found online homework had a statistically positive effect on achievement and half found no statistical difference. All of the studies that researched student opinion found positive results. While conclusions about student opinion are universal, conclusions about student achievement are confounding. Further analysis done in the current study aims to determine factors that may cause contradictory results. Table 1 below summarizes the sixteen studies.

Table 1: Summary of Research on the Use of Online Homework with College Mathematics

Authors	Sample size, Subject	Does online homework statistically produce greater achievement?	Positive student opinion
Pierce and Stacey (2001)	30, Calculus	n/a	yes
Carter (2004)	55, Basic Mathematics	No statistical difference	n/a
Hagerty and Smith (2005)	251, College algebra	yes	yes
Butler and Zerr (2005)	408, College algebra and calculus	n/a	yes
Jacobson (2006)	276, Prealgebra	No statistical difference	yes
Zerr (2007)	27, Calculus	yes	yes
Taylor (2008)	93, Intermediate algebra	yes	yes
Kodippili and Senaratne (2008)	72, College algebra	No statistical difference, p-value= .0638	n/a
Smolira (2008)	80, Finance	n/a	yes
Stillson and Nag (2009)	210, Remedial algebra	n/a	yes
Lenz (2010)	191, Math survey	No statistical difference	yes
Burch and Kuo (2010)	52, College algebra	Yes on exams, no on final exam	n/a
LaRose (2010)	665, 2nd semester calculus	No statistical difference	yes
Brewer and Becker (2010)	145, College algebra	No statistical difference overall, yes for low incoming skill	yes
Cox and Singer (2011)	87, Calculus	n/a	yes
Halcrow and Dunnigan (2012)	232, Calculus	Yes for one instructor, no for the other	yes

Summary

Non-traditional and minority students are overrepresented in developmental education (Mulvey, 2009). The current study focuses on non-traditional and Alaska Natives students. The use of varied instructional methods, use of technology, providing frequent and timely feedback, use of mastery learning, and sharing of instructional practices are five specific recommendations from experts in the field of developmental education that relate to the current study (Boylan, 2002). Developmental educators must consider the affective needs of students. Therefore, an important component of the current research is student opinion and attitude.

American Mathematical Association of Two Year Colleges (AMATYC, 2006), and the National Council for Teachers of Mathematics (NCTM, 2000) recommend the use of technology. The National Association of Developmental Mathematics (Boylan, 2002) recommends the use of technology in moderation. Consistent with this recommendation, all sections in this study were face-to-face lecture style classes. Experimental sections used online homework, while control sections used paper sections.

Research on the use of online homework as it exists today has only been in conducted for about a decade. Older research examined computer assisted learning that was implemented in a whole class computer lab setting (Pierce & Stacey, 2001). Limiting the search to research on the use of online mathematics homework at the post secondary level yielded a very small number of studies.

The following themes appeared. First, student opinion of online homework is favorable. A few studies also surveyed instructors and those results were generally favorable (Halcrow & Dunnigan, 2012; LaRose, 2010; Jacobson, 2006).

Second, there were inconsistent results regarding achievement. About half of the studies demonstrated a positive effect on achievement. The other half of the studies showed no significant difference. No studies found a negative effect. Most studies that did not find a statistical difference in achievement cited small sample size as the reason. In an effort to overcome this limitation, this study includes a larger number of sections (19 sections) of developmental math. However, a quick analysis on the sixteen previous studies produced no discernable pattern between sample size and statistical significance. For the five studies that analyzed achievement and had sample size less than 100: two found a positive effect, two found no effect and one had mixed results. For the five studies that analyzed achievement and had sample size more than 100: one found a positive effect, three found no effect, and one had mixed results.

Several of the studies used multiple instructors, as does the current study. But only one study analyzed how the different instructor factor interacted with the effect of online homework (Jacobson, 2006). The current study will analyze how six different instructors interact with the effect of online homework.

Two studies included multiple course levels (Smolira, 2008; Butler & Zerr, 2005), but only one study analyzed how the course level interacted with the effect of online homework (Smolira, 2008). The current study will analyze how four different course levels interact with the effect of online homework.

Several of the studies looked at the backgrounds of the students (Zerr, 2007; Hagerty & Smith, 2005). Background factors included were gender, GPA, and ACT/SAT scores. But none of the studies analyzed the interaction of sub-populations with the effect of online homework. The current study will analyze how non-traditional status and Alaska Native status interact with the effect of online homework.

Two studies used the Fennema-Sherman Mathematics Attitude Scale to measure attitude (Carter, 2004; Taylor, 2008). One study found no significant difference in attitude (Carter, 2004) and the other study (Taylor, 2008) did find a significant difference in attitude. The current study will use this instrument to measure attitude.

In summary, this chapter reviewed current literature on mathematics homework, developmental education, and online homework in post secondary mathematics. Chapter Three will describe the methodology, including the research design, participants, instrumentation, data collection, analysis procedures and limitations of the study.

Chapter 3 Methodology

Introduction

The purpose of the study is to analyze the effects of online homework on achievement, persistence, and attitude, with special focus on non-traditional and Alaska Native students.

This study examined the following research questions:

1. To what extent does online homework affect the achievement of students enrolled in developmental mathematics courses, as measured by a post-test, final course grade, and pass rates?

2. To what extent does online homework affect the persistence of students enrolled in developmental mathematics courses, as measured by attendance and withdrawal rates?

3. To what extent does online homework affect the attitudes of students enrolled in developmental mathematics courses, as measured with the Fennema-Sherman Mathematical Confidence and Mathematical Usefulness Scales, and homework questionnaires?

This chapter describes the methods and procedures that were used in this study.

Research Design

Four levels of developmental mathematics classes were involved: pre-algebra, beginning algebra, intermediate algebra, intensive intermediate algebra. For this study six instructors (A-F) taught a total nineteen sections as shown Table 2. Nine sections of developmental mathematics courses served as the control group (paper homework) and ten sections of developmental mathematics were assigned to the treatment group (online homework).

Table 2: Participating Sections of Developmental Math by Instructor (A-F)

Homework type	Pre-algebra	Beg. Algebra	Int. Algebra	Intensive Int. Algebra
Paper (control)	A, B, C	D, E	A, B, F	E
Online (treatment)	A, B, C	D, E	A, A, B, F	E

This study used an experimental design approach. Experimental research designs can be useful for drawing inferences about the effectiveness of mathematics curricula (Carnine, 2000). The treatment group for this study received online homework and the control group used paper and pencil homework. The dependent variables examined are mathematical achievement, persistence, and attitude. Three measures of achievement were used. Achievement was measured post-test, final course grade, and pass rates. Two measures of persistence were used: attendance rates and withdrawal rates. Three measures of attitude were used: Fennema-Sherman Usefulness Scale, Fennema-Sherman Confidence Scale, and homework questionnaires. The independent variable in this study is homework type.

The experimental design was a partially balanced incomplete block design. The design is balanced in that each instructor taught at least one section with online homework and one with paper homework. It is partially balanced because each instructor did not teach the same number of sections. It is incomplete because each class does not have the same number of sections of each class level. This limitation is due the varied demand for the courses, thus is unavoidable. Each instructor served as a blocking factor.

The following covariates were considered: pre-test, course level, instructor, times class met per week, time of day, Alaska Native status, and non-traditional status. The covariates Alaska Native and non-traditional status were analyzed to determine if these independent variables were significantly related to the use of online homework.

The following measures were taken to minimize statistical bias and variability:

1. Each instructor taught both at least one control section (paper homework) and one experimental section (online homework) at the same course level.

2. An attempt was made to have each instructor teach multiple course levels (pre, beginning, intermediate and intensive intermediate algebra). However, this was not possible with all instructors. Three instructors taught multiple levels: instructor A, B and D. Three instructors taught one level: C, E, F.

3. An attempt was made to have each course level taught by multiple instructors. This was possible in all levels except intensive intermediate algebra.

4. To reduce statistical variability due to student-to-student variation and to achieve a greater degree of reliability, mathematical achievement was measured by the pre- and post-test performance.

5. To reduce the class-to-class variation the following additional data was collected: time of day (morning or afternoon) and the number of times the class met per week (two or three).

This study also administered a homework questionnaire. Responses were numerical and quantitative analysis methods were employed. Responses were compared using the Wilcoxon Rank-Sum Test (Devore, 2000).

Participants

The study was conducted at a public, four-year university with an embedded community college component, located in Fairbanks, Alaska. According to the U.S. Census Bureau the estimated Fairbanks North Star Borough population is 100,272 (2014). The University of Alaska Fairbanks institutional profile (2014) indicates there are approximately 10,800 enrolled students. The median age of students is 25 years old. Alaska Native/ American Indians comprise 19.7 percent of the student population.

The University of Alaska Institutional Review Board approved the implementation of this research project. Approval was given on May 10, 2012 for project titled *Analysis and Comparison of the Effects of Online Homework on Achievement, Persistence, and Attitude in Developmental College Mathematics Students* [329093-1] (see Appendix A). Informed consent to participate in this study was obtained from each of the study participants before the implementation of the research experiment. Informed consent was given by participating instructors and students (see Appendices B and C).

All full-time instructors teaching developmental mathematics in the fall 2012 semester were given the choice to participate in the study. Six out of eight full time instructors volunteered to participate. Five of the instructors were experienced teachers, ranging from ten to twenty five years of experience. One of the instructors had one year of teaching experience. Four instructors have a master's degree in mathematics. One instructor was finishing a master's degree in mathematics. One instructor has a bachelor's degree in mathematics and a master's degree in education.

One of the instructors is also the researcher for this study, as this is an action based research project. The researcher is aware of the potential for bias, and acted in a professional manner both as an instructor and as a researcher. Students were informed of the instructor's role in the research process, and were given the information on the written consent form. Action based research is a valid form of research in which the research takes place in a real-world situation and aims to solve real problems (Johnson, 2008).

The student participant sample (n= 423) came from those enrolled in the sections of the participating instructors. The sample came from 19 out of a total of 34 sections of developmental mathematics sections taught Fall 2012.

Six out of eight sections of pre-algebra are represented in the survey. Part-time faculty taught the other two sections. Four out of ten sections of beginning algebra, and seven out of fourteen sections of intermediate algebra are represented in the study. Intensive intermediate algebra is an optional four-credit class that can be taken in lieu of intermediate algebra. There are only two sections offered by the same instructor, and both are represented in the study.

Sections were assigned the use of online or paper homework prior to student registration. Effort was made to keep this information private from students prior to the start of the semester. Students did not know if they were registering for a section using online or paper homework. However, some of developmental mathematics instructors have been using online homework for the prior four years. Some students expected to have or not have online homework by taking a certain instructor. After the first day of class, some students may have reassigned themselves to sections that had a homework style of their preference. There were very few students who changed sections and their reasons for changing sections was not documented.

Instrumentation

Fennema-Sherman Mathematics Attitude Scale: Fennema-Sherman Mathematics Attitude Scale (see Appendix D) was used to document students' opinion and attitude toward learning mathematics. This survey was administered during the first week of the semester and again the last week of the semester. Fennema-Sherman Mathematics attitude scale, was first developed in 1976 and later revised. This research tool as been well studied and is determined to be valid and reliable (Fennema & Sherman, 1976).

Two scales from the Fennema-Sherman Mathematics scales were used in this study: personal confidence and usefulness. The confidence scale was used to measure the change in students' confidence in their own mathematical ability from the beginning to the end of the semester. The usefulness scale was used to analyze the student's belief that mathematics is useful in general and to their future education. Analysis was conducted on the changes to the mean scores from the beginning to the end of the semester.

The Modified Fennema-Serman consists of 24 statements worded in the first person. For example “Math is a worthwhile, necessary subject”. Students are asked to respond to each statement on a 5 point Likert-type scale. Each scale has six items that measure positive attitude and six items that measure negative attitude. Each positive item receives a score of 1 to 5 (1 being least positive, 5 being most). The scoring for the negative items are reversed so that 1 is the most negative and 5 is the least negative. The highest possible score for each scale is 60 points.

The attitude survey was given confidentially, but not anonymously. As recommended by Dillman (2000) questionnaires will produce more reliable results if the survey is conducted confidentially and if efforts are made to protect participant identity. To ensure confidentiality, identifying numbers (instead of student names) were used. Complete explanation was given to students to explain why the identifiers were needed. Students were assured that the identifying data was only available to the researcher.

Student Characteristic Survey: To determine non-traditional and Alaska Native status a student characteristic survey was given the first week of class (see Appendix E). Students self reported ethnicity. Students were also asked to indicate which of the seven National Center for Education Statistics (NCES, 2012b) traits defining a non-traditional student applied to them. As with the attitude survey and pre-test, the student characteristic survey was given confidentially, but not anonymously.

Pre-Tests of Mathematical Knowledge: Prior to the start of the semester, pre-tests (see Appendix F, G, and H) were developed for each course. The researcher drafted a pre-test for each level: pre algebra, beginning algebra, intermediate algebra. The same pre-test was given to intermediate and intensive intermediate algebra. The participating instructors revised and approved the final copies. The test reflected the desired student learning outcomes for each course. The pre-test was administered to both the treatment and the control group of students during the first week of classes. This testing instrument was used to determine the students' pre-existing mathematics skills. Each pre-test was a one-hour, paper and pencil, multiple-choice, in-class exam. All pre-tests were collected and given to the researcher for scoring. Each question was weighted equally to produce a possible scoring range of 0 to 100 percent. Pre-tests were not returned to the students or to the instructors. With the exception of the researcher/instructor, results were not reported to the instructors. The pre-test was not part of the students' grade.

Post-Tests of Mathematical Knowledge: The post-test instruments were the common departmental comprehensive final exam for each course. Each instructor graded their own final exams and reported the scores to the researcher. Each exam was worth 0 to 100 points. Due to the confidential nature of common final exams these instruments are not being provided in the appendix, but are available upon request.

Online Homework for Pre-algebra: The same publisher developed the pre-algebra online homework program; *MyMathLab,* and textbook. Homework problems were highly aligned with the textbook and were often exactly the same problems given in the textbook. In advance of the beginning of the semester the instructors created homework assignments that are aligned with each lecture. The instructor decided the settings: the type and number of problems, the type of tools available to students, due dates, and number of attempts allowed. For this study the setting were uniform for all pre-algebra sections. Specifically there were unlimited attempts of similar (not exactly the same) problems, daily due dates, and consistent tool availability. For pre-algebra all three sections assigned 20 problems daily.

The tools available to the students included links to worked examples, videos of examples, and links to portable document files (pdf) of the textbook. Also, if the problem was multi-step the student could click on a link that would give the next step. If the student did not get the answer correct, the program gives the correct answer and a link appears for an opportunity to try a similar problem. If the student incorrectly answered a type of problem in three consecutive attempts, the program guided them to different type of problem. Students would continue on the homework set, but could go back to any incorrect problems and redo with a similar problem. This meant that to earn 100 percent they only had to redo the problems they got wrong. Students typically took advantage of multiple attempts, so the homework grades were often 100 percent. It is recognized that there is a potential for an inflation of overall grade due to the multiple attempts allowed with online homework. However, separate analysis of overall course grades *without* homework was not done for this study.

To access the program students would need the course code given to them by the instructor and a student access code that came with the textbook. They would follow the directions given with the syllabus for registering with the program and using the tutorial to learn how to enter answers.

By consensus of the instructor participants, homework was worth 30 percent of the final course grade for both the control and experimental groups. This percentage may be higher than the typical course taught at this university. However, for consistency in this study the instructors agreed to 30 percent. A sample syllabus is included in Appendix K. Online homework was used exclusively for the experimental sections. No paper and pencil homework was assigned to or collected from the experimental sections. The program graded online homework assignments. No partial credit was given.

Online Homework for Beginning, Intermediate, and Intensive Intermediate Algebra: These courses used a different online homework program than the pre-algebra course. This program, *ALEKS (Assessment and Learning In Knowledge Spaces),* had two homework features. One feature was directly aligned with the textbook and the other feature was an individualized study guide.

The first homework feature was similar to the pre-algebra program. The instructor preselected exercises and specific deadlines. The exercises were aligned with the lecture and the textbook. Assignment length varied from five to twenty problems. Assignment length varied from assignment to assignment and from instructor to instructor. The instructors decided how many times the assignment could be attempted. In this study all online homework was allowed unlimited attempts of similar (not exactly the same) problems.

The second homework feature was not directly aligned with the textbook, but was individualized based on student performance on intermittent, automated assessments. The instructor pre-determined the topics for the entire semester. Depending on the course level there were between 120-180 topics per course. When the student initially logged into the program they were given a pre-test. The pre-test determined which of the topics the students had mastered. The remaining topics must be "earned" by correctly completing three consecutive problems. Assessments were periodically given to determine if the student retained mastery of the topics. If the student did not retain mastery, then the topic needed to be relearned, and mastery needed to be re-demonstrated.

The instructor grouped the topics so they were released to students roughly as they were presented in class. This homework feature was not aligned at the lecture level. Each student had different topics to master, depending on how they performed on the assessments. Instructors set deadlines for the groups of topics, but not for individual topics. In both features of this program students had tools available to them such as videos, links to portable document files (pdf) of the textbooks, and worked examples.

Again, all homework was worth the same amount (30 percent) of the final grade calculation. Online homework was used exclusively for the experimental sections. No paper and pencil homework was assigned or collected for the treatment sections. The program graded online homework assignments. No partial credit was given.

Both sections of beginning algebra were assigned about ten homework problems, with unlimited attempts, per day. One section also used and graded the individualized study guide.

All four sections of intermediate algebra had consistent settings. The courses settings (homework, due dates, tools available, number of attempts) were created in *ALEKS.* Then the entire course was copied for each of the instructors. This means all sections assigned the same number homework problems, with unlimited attempts of similar problems and graded the individualized study guide.

Paper Homework: In the control group, paper homework was assigned from the required textbooks and graded by the instructors. All sections of pre-algebra used the same textbook. All sections of intermediate algebra used the same textbook and all sections of intensive intermediate algebra used the same textbook. However, there were two textbooks used for beginning algebra. Instructor D used a different textbook then instructor E. Regardless of the textbook the student learning outcomes were consistent for each class. The textbooks covered the same material. Instructors were given the discretion to organize and teach each class as they have prior to this study.

As with the experimental sections, instructors agreed to consistent weighting of homework for final grade calculation (30 percent). In the control sections, each instructor chose how to assign and grade paper homework. Some collected homework weekly, others daily. Some instructors graded 5 out of every 20 problems, while other instructors graded every problem. Paper and pencil homework was used exclusively for the control sections. No online homework was assigned or collected for the control group. Partial credit was allowed.

Other instructional feedback: This study did not analyze the effects of other feedback given, but it is important to bear in mind other written feedback was given to students. For all sections of pre-algebra, intermediate algebra, and intensive intermediate algebra weekly paper quizzes (graded by the instructor) were given. For all sections of beginning algebra no paper quizzes were given. Paper and pencil exams (graded by the instructor) were given for all sections. All paper exams and quizzes were open-response and graded with partial credit.

Homework Questionnaire: Student and instructor questionnaires were administered during the last week of instruction. Students were asked five questions about how they felt about the homework format (Appendix I). The directions were to rank the statements on how much you agree with the statement given. The scale was strongly disagree, disagree, neutral, agree, strongly agree. The five questions were:

1. The homework for this class helped me learn the material.

2. The homework for this class helped my final grade in this course.

3. I did my homework for this class most of the time.

4. I believe doing homework is valuable.

5. I am satisfied with the homework format for this class (online for some students, and paper and pencil for other students).

Instructors were given almost identical statements (see Appendix J). For example, students were given the following statement "The homework for this class helped me learn the material", while the instructors were given two statements: "Online homework helped students learn the material," and "Paper and pencil homework helped students learn the material."

Data Collection Procedures

All instructors of developmental mathematics at the University of Alaska Fairbanks were invited to participate; six out of eight chose to participate. Students enrolled in developmental mathematics classes based on the mandatory placement policy using acceptable placement methods and scores. Students did not know if they enrolled in a section that was assigned online or paper homework. On the first day of class, all students enrolled in the sections involved in the study were asked to participate. Students were informed of their rights and gave their consent for participation.

A confidential identification system was prepared prior to the first day of class. Each student's name was randomly assigned a seven digit code. Five digits were the university assigned course reference number (CRN) and two were random numbers. The statistical program "*R*" (widely available, free software for statistical computing) was used to randomize the numbers before they were assigned to the class list. Four address label stickers were prepared with each identification code. The first sticker was placed on the student characteristic survey, the second sticker was put on the pre-attitude survey, the third sticker was put on pre-test and the fourth sticker was used on the post-attitude survey. Each time, care was taken to ensure the identification code was matched to the correct student. The master list of identification code and student names was kept in a secure location during the course of the study and was destroyed after the study concluded per the Institutional Review Board (IRB) approval.

After appropriate consent was gathered, the experiment began with initial student characteristic survey to collect data on non-traditional and Alaska Native status. Then the Modified Fennema- Sherman Mathematics Attitude Survey was administered.

During the first week of instruction a pre-test was administered to measure the baseline of mathematical achievement. A one-hour class period was devoted to the pre-test. Students' were assured the pre-test did not have any bearing on their grade. The confidential identification system was again used.

After the student characteristic survey, attitude survey, and pre-test were administered, the semester proceeded as normal. Instructors were encouraged to not alter their teaching styles and to offer consistent lectures and expectations to control and experimental sections. They were asked to take attendance.

During the last week of instruction a post-attitude survey was administered. The confidential identification system was used with the post-attitude survey so it could be paired with the pre-attitude survey. Students were also given a homework questionnaire to determine how they felt about the homework format. Care was taken to ensure student confidentiality.

The common departmental final exam score was used as a measure of mathematical achievement. Each instructor graded the final exams completed by their own students. Common final exams are administered as the part of the usual education practice so the confidential identifier system was not used.

Participating instructors also received a homework questionnaire on how they felt about the homework format. At the end of the semester instructors reported the final course grades, the final exam scores, and attendance.

The following data for each student was entered into *FileMaker Pro*: Alaska Native status, non-traditional status, homework type, pre and post-test scores, pre and post attitude scores, attendance, final course grade, time of day class met, number of times per week class met, instructor, and course level. The statistical program *R* was used for the data analysis.

Data Analysis Procedures

Statistical analysis was done in the computer program *R*, except as noted. There were seven dependent variables summarized in Table 3. Homework type was the independent variable of main concern, but there were a total seven covariates considered, summarized in Table 4.

Table 3: Dependent Variables

Dependent Variables	Measure of	Type of variable	Possible Values
Post-test	achievement	continuous	0-100
Final course grade	achievement	ordinal	A, B, C, D, F, U, W
Pass/ Fail	achievement	binary	Pass=1, fail=0
Attendance	persistence	continuous	0-100
Withdrawal/ Not withdrawal	persistence	binary	Withdrawal=1, not withdrawal=0
Change in attitude: usefulness	attitude	continuous	0-60
Change in attitude: confidence	attitude	continuous	0-60

Table 4: Independent Variables

Independent Variables	Main or Covariate	Possible values
Homework Type	main	Online=O, Paper=P
Pre-test	covariate	0-100
Algebra Course level	covariate	Pre= A, Beg=B, Int=C, Intensive Int= D
Instructor	covariate	A, B, C, D, E, F
Times per week class met	covariate	2, 3
Time of day	covariate	Morning=M, Afternoon: A
Alaska Native status	covariate	Native= Y, Not Native= N
Non-traditional	covariate	Non-traditional= Y, Traditional= N

When the dependent variable was continuous multiple-factor analysis of variance (ANOVA) was used to investigate the main effects of the independent (Kutner, Nachtsheim, Neter & Li, 2005). The main effect is the effect of the predictor variable on the response variable. When the effect of one predictor variable depends on the levels of other predictor variables the interaction of these effects can be important. Therefore, the interaction effect of homework type and all the other predictor variables on the dependent variable was also analyzed. For example, the effect of the interaction of homework type and instructor may have a significant effect on post-test scores.

The F test based on the type III estimable functions for each effect was used to test if the effect of a term might be statistically significant; under the assumption that the sampled populations are normally distributed. In general, the null and alternative hypotheses for testing each effect are:

H_0: There was no relationship between the dependent variable and the factor of interest.

H_a: There was a relationship between the dependent variable and the factor of interest.

In general, without further specification, a p-value less than 0.05 indicates that the effect was statistically significant. If the interaction effect was significant, simple effect (a simple effect of an independent variable is the effect at a single level of another variable) was investigated and p-value was adjusted using Bonferroni method for multiple comparisons (Kutner, Nachtsheim, Neter & Li, 2005).

If the effect of a factor with more than two levels was significant, pairwise comparison was performed to see which two levels were statistically significantly different. To control for the family wise error rate, the multiple comparison procedure, Tukey-Kramer's method was implemented (Kutner, Nachtsheim, Neter & Li, 2005).

Estimated marginal means and the associated standard error (SE) for factors with significant effects were reported. Estimated marginal mean of a factor is the mean response of the factor after adjusting for any other variables in the model.

The three assumptions of ANOVA need to be satisfied: 1. independence of observations (residuals are independent), 2. normality (the distributions of the residuals are normal), and 3. homoscedasticity (the residuals have constant variance).

Normality was examined though skewness, kurtosis, Shapiro-Wilk test of normality (Kutner, Nachtsheim, Neter & Li, 2005), and the quantile-quantile (Q-Q) plot.

The sample skewness measures the tendency of the deviations to be larger in one direction than in the other. Skewness is a measure of symmetry. Observations that are normally distributed should have a skewness near zero (as normal distribution is symmetric). A negative skew indicates that the tail on the left side of the probability density function is longer than the right side and the bulk of the values lie to the right of the mean (skewed to the left). A positive skew indicates that the tail on the right side is longer than the left side and the bulk of the values lie to the left of the mean (skewed to the right).

The sample kurtosis measures the peakedness of the distribution and the heaviness of its tail (relative to a normal distribution). Observations that are normally distributed should have a kurtosis near zero. A high kurtosis distribution has a sharper peak and longer, fatter tails, while a low kurtosis distribution has a more rounded peak and shorter, thinner tails.

The Shapiro-Wilk test procedure is a goodness-of-fit test for the null hypothesis that the values of the analysis variable are a random sample from the normal distribution. p-value less than 0.05 of the Shapiro-Wilk test leads to the rejection of the null hypothesis of normality.

The quantile-quantile (Q-Q) plots compare ordered variable values with quantiles of a specified theoretical distribution (in our case, normal distribution). If the data distribution matches the theoretical distribution, the points on the plot form a linear pattern - following the 45 degree straight line.

The residual plot (residuals versus the fitted values) was used to investigate if the variances are constant/equal. Plotting residuals versus the value of a fitted response should produce a distribution of points scattered randomly about 0, regardless of the size of the fitted value. The residuals should be unbiased (the average value of residuals in any vertical strip should be zero) and homoscedastic (homogeneity of variance- the spread of the residuals should be the same in any vertical strip).

ANOVA models are, in general, robust against minor violations of the model assumptions, such as the error terms are not exactly normally distributed or when the error variances are unequal but all factor level sample sizes are approximately equal (Kutner et al., 2005). However, if the ANOVA assumptions are seriously violated and sample sizes are not approximately equal, the analysis results from the ANOVAs should be interpreted with caution, and data transformation is recommended to be applied to the dependent variable to stabilize the variances (Kutner et al., 2005).

When the dependent variable was categorical with binary responses (pass rate and withdrawal rate), multiple logistic regression for binary responses was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Instructor, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable.

The type 3 analysis of effects based on the Wald χ^2 (Agresti, 2002) test was used to determine if an effect was statistically significant. The null and alternative hypotheses for each effect are:

H_0 : There was no relationship between the dependent variable and independent variable X.

H_a : There was a relationship between the dependent variable and independent variable X.

P-value less than 0.05 resulted in the rejection of the null hypothesis. Hosmer-Lemeshow goodness-of-fit tests was used to determine the model adequacy; where p-value > 0.05 indicates good model fit (Agresti, 2002).

When the dependent variable was final course grade (5 levels: A, B, C, D, F, as U and W were not used in the modeling process), ordinal logistic regressions (Agresti, 2002), in specific, proportional odds models were proposed to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Instructor, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable.

The validity of the proportional odds assumption can be checked based on a χ^2 Score test (Agresti, 2002). A non-significant test result (p-value > 0.05) indicates the proportional odds assumption is satisfied.

The type 3 analysis of effects based on the Wald χ^2 test was used to determine if an effect was statistically significant. The null and alternative hypotheses for each effect were:

H_0 : There was no relationship between the response variable and independent variable X.

H_a : There was a relationship between the response variable and independent variable X.

P-value less than 0.05 resulted in the rejection of the null hypothesis. Hosmer-Lemeshow goodness-of-fit tests was used to determine the model adequacy (p-value > 0.05 indicates good model fit).

Note that if the proportional odds assumption is violated, rather than proportional odds models, multinomial logistic regression (Agresti, 2002) would be used for the data analysis. The deviance and the Pearson goodness-of-fit tests (Kutner et al., 2005) were used to determine the model adequacy, where p-value > 0.05 indicates good model fit.

The Wilcoxon Rank-Sum test provides a method for comparing two sample means without any assumptions about the underlying distributions (Devore, 2000). The Wilcoxon Rank-Sum test was used to determine if the means responses to the homework questionnaire were different between the online homework group and the paper homework group and between instructor and students. Additional analysis was done on the Alaska Native and non-traditional subpopulations.

Limitations

The researcher is also one of the instructors involved in this study. Care was taken to not coerce any student or instructor involved. Every attempt was made to minimize the effects of extraneous variables. Extraneous variables that cannot be controlled include students' motivation, personality, environment, teacher personality, social factors, gender, and socio-economics. All these factors, and many others, may have an effect on students' achievement, attitude and persistence in courses. Variability between instructors is to be expected. It is unavoidable and is a limitation of this study. This study used a multiple-choice pre-test. This measure of previous mathematical achievement has limitations. The multiple choice format can lead to correct answers that do not indicate understanding, and incorrect answers that do not indicate a lack of understanding. Despite this, it was desirable to use an up-to-date measure of achievement, rather than a possibly obsolete measure such as SAT or ACT score. This study assumed the common final exam administered as the post-test is a reliable and valid measure of student achievement in mathematics. This study used a pre-test-post-test control group research design that assumed that the experimental group and the control group are comparable with regard to their performance on the pre-test.

The results for this study only apply to developmental mathematics students at the University of Alaska Fairbanks. However, it is possible that the results can be applied to other levels of mathematics or other subjects.

Summary

An experimental design was employed. Ten sections of developmental math used online homework and served as the treatment group for this study. Nine control sections used paper homework.

The independent variable was homework type. The dependent variables were achievement, persistence, and attitude. Achievement was measured by post-test, final course grade and pass rate. Persistence was measured by attendance and withdrawal rate. Attitude was measured by surveys on mathematical usefulness and confidence. Attitude was also explored with homework questionnaires. The following covariates were considered: pre-test score, course level, instructor, times class met per week, time of day, Alaska Native status and non-traditional status. Non-traditional and Native statuses were determined by a student characteristic survey.

To ensure confidentiality all student participants were assigned a random confidential identifying number. The number was applied to the student characteristic survey, pre-test, and to the pre- and post-attitude surveys.

Analysis of variance was used to analyze the relationship between homework type and continuous dependent variables: post-test, changes in attitude of usefulness, change in attitude of confidence and attendance. Multiple logistic regression was used to analyze the relationship between homework type and binary dependent variables: pass rate and withdrawal rate. Proportional odd modeling and multinomial logistic regression was used to analyze the relationship between homework type and the ordinal dependent variable final course grade.

Responses to the homework questionnaire were numerical. The Wilcoxon Rank-Sum test was used to determine if statistical differences existed between control and experimental groups and between instructor and student responses to the homework questionnaire.

This chapter described the methodology, including the research design, participants, instrumentation, data collection, analysis procedures, and limitations of the study. Chapter Four will present the results of this research.

Chapter 4 Results

Introduction

The purpose of the study is to analyze the effects of online homework on achievement, persistence, and attitude, with special focus on non-traditional and Alaska Native students.

The descriptive statistics are summarized in tables 5, 6 and 7. There were 423 subjects in total.

Table 5: Summary Statistics, Continuous Variables

Variable	N	Mean	SD	Min	Max
Attendance	340	80.87	17.86	7	100
Pre-test	394	57.96	18.70	5	100
Post-test	323	72.21	15.85	17	100
Changes in attitude of usefulness of math	290	-1.37	7.41	-29	30
Changes in attitude of confidence in math	290	0.70	7.47	-27	26

Table 6: One-way frequency table, Categorical Variables

Variable		Frequency	Percentage
Native	No	307	78.52
	Yes	84	21.48
Course level	A	115	27.19
	B	94	22.22
	C	159	37.59
	D	55	13.00
Final course grade	A	84	19.86
	B	87	20.57
	C	88	20.80
	D	42	10.64
	F	69	16.31
	U	8	1.89
	W	42	9.23
Pass rate	Fail	156	37.59
	Pass	259	62.41
Withdrawal rate	Not withdrawal	373	89.88
	Withdrawal	42	10.12
Instructor	A	110	26.00
	B	87	20.58
	C	30	7.09
	D	41	9.69
	E	108	25.53
	F	47	11.11
Non-traditional	No	210	53.57
	Yes	182	46.43
Time of day	Morning	208	49.17
	Afternoon	215	50.83
Times per week	2	120	28.37
	3	303	71.63

Table 7: Two-way frequency table, Select Categorical Variables

		Frequency	Percentage		Frequency	Percentage
Online HW	Native	50	24.51	Non-Traditional	99	48.29
	Non-Native	154	75.49	Traditional	106	51.71
	Total	204		Total	205	
Paper HW	Native	34	18.18	Non-Traditional	83	44.39
	Non-Native	153	81.82	Traditional	104	55.61
	Total	187		Total	187	

Multicollinearity, Singularity, and Completion Separation

During the modeling process it was discovered that not all the independent variables (Homework type, Pre-test, course level, Instructor, Times per week, Time of day, Native, Non-traditional) can be included in the fitted model. For each dependent variable, a model with the main effects only was created. For ANOVA, there was a problem of multicollinearity (two or more predictor variables are highly correlated) as one of the coefficients estimation was *NA*. For logistic regression, there was a problem of singularity as one of the coefficients estimation was *NA*. Singularity means that your predictor variables are linearly dependent, i.e. one of the variables can be expressed as linear combination of other variables. In addition, for logistic regression, (quasi) complete separation was also a common issue. A complete separation happens when the outcome variable separates a predictor variable or a combination of predictor variables completely. After removing one independent variable at a time out of the model, it was suggested that the variable "Instructor" could be excluded from the modeling process.

In addition, the association between Instructor and the other covariates (Homework type, course level, times per week, time of day, native, non-traditional) was also investigated via Chi-square test of independence (Kutner et al., 2005), results shown below:

- There was no association between Instructor and homework type ($p = 0.1303$).
- There was an association between Instructor and course level ($p < 0.0001$).
- There was an association between Instructor and times per week ($p < 0.0001$).

- There was no association between Instructor and native (p = 0.2572).
- There was an association between Instructor and non-traditional (p = 0.0042).

This shows that the variable "Instructor" was indeed strongly associated with at least one other independent variable. Therefore, the variable "Instructor" was not used in any of the fitted models.

Research Question One: Achievement

To what extent does online homework affect the achievement of students enrolled in developmental mathematics courses, as measured by a post-test, final course grade, and pass rates?

Post-Test of Mathematical Knowledge

In this section, ANOVA was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, post-test. Figure 1 shows the histogram plot of the dependent variable, post-test.

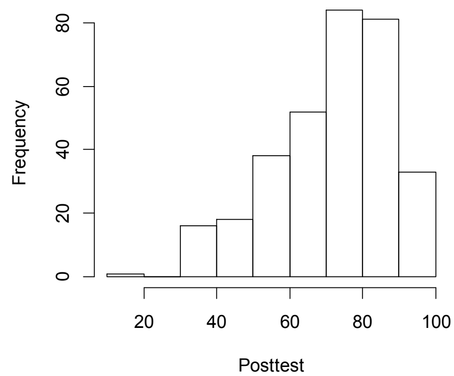


Figure 1: Histogram plot of the dependent variable, post-test

For the interaction effects, the results of the F test indicate that:

- The interaction effect of homework type and times per week was not statistically significant at the 0.05 level (F (1, 284) = 0.01, p = 0.9129).
- The interaction effect of homework type and time of day was not statistically significant at the 0.05 level (F (1, 284) = 2.54, p = 0.1123).
- The interaction effect of homework type and non-traditional was not statistically significant at the 0.05 level (F (1, 284) = 0.02, p = 0.8969).
- The interaction effect of homework type and native was not statistically significant at the 0.05 level (F (1, 284) = 1.26, p = 0.2625).
- The interaction effect of homework type and pre-test was not statistically significant at the 0.05 level (F (1, 284) = 0.86, p = 0.3558).
- The interaction effect of homework type and course level was statistically significant at the 0.05 level (F (3, 284) = 4.33, p = 0.0053). This suggests that the

effect of homework type on post-test scores depends on course level, and vice versa. Table 8 shows the estimated marginal means of post-test under each level of homework type by course level.

Table 8: Estimated marginal means of post-test under homework type X course level

Homework type	Course level	Estimated marginal means	Standard error
O	A	65.37	2.94
P	A	68.94	2.59
O	B	73.36	3.51
P	B	59.62	3.27
O	C	75.99	2.12
P	C	67.78	3.23
O	D	63.37	3.89
P	D	71.13	4.93

It appears that the effect of homework type:

- Under course level = “A”, the effect of homework type on post-test was not statistically significant at the 0.05 level (F (1, 284) = 0.83, p = 1.000).
- Under course level = “B”, the effect of homework type on post-test was statistically significant at the 0.05 level (F (1, 284) = 8.18, p = 0.018).
- Under course level = “C”, the effect of homework type on post-test was not statistically significant at the 0.05 level (F (1, 284) = 4.52, p = 0.137).
- Under course level = “D”, the effect of homework type on post-test was not statistically significant at the 0.05 level (F (1, 284) = 1.53, p = 0.870).

For the main effect (only investigated if interaction effect was not statistically significant), the results of the F test indicate that:

- The effect of times per week was not statistically significant at the 0.05 level (F (1, 284) = 2.69, p = 0.1018).
- The effect of time of day was not statistically significant at the 0.05 level (F (1, 284) = 0.00, p = 0.9450).
- The effect of non-traditional was statistically significant at the 0.05 level (F (1, 284) = 8.41, p = 0.0040). The estimated marginal means of post-test (standard error in parentheses) for non-traditional = N and Y were: 65.76(1.56) and 70.63(1.65), respectively. There was a statistically significant difference on the means of post-test between traditional and non-traditional groups.
- The effect of native was statistically significant at the 0.05 level (F (1, 284) = 17.54, $p < 0.0001$). The estimated marginal means of post-test (standard error in parentheses) for native = N and Y were: 72.65(1.16) and 63.74(2.15), respectively. There was a statistically significant difference on the means of post-test between native and non-native students.
- The effect of pre-test was statistically significant at the 0.05 level (F (1, 284) = 41.28, $p < 0.0001$).

Based on the results of parameter estimation, the fitted model could be written as:

Post-test = 46.26 -1.83*I(Homework type) + 0.37*Pretest + 4.45*I(native) - 2.44*I(nontraditional) - 1.04*I(course level1) - 1.71*I(course level2) + 3.69*I(course level3) – 0.07*I(Time of day)- 2.00*I (Times per week) + 0.05*I(Homework type)*Pretest -1.19*I(Homework type) *I(native) -1.11*I(Homework type)*I(nontraditional) – 3.11*I(Homework type)*I(course level1) + 5.54*I(Homework type)*I(course level2) + 2.78*I(Homework type)*I(course level3) -1.67*I(Homework type)*I(time of day) -0.13*I(Homework type)*I(times per week), where, based on dummy coding (i.e. coding which includes only 0 and 1 to indicate group membership):

- I(Homework type) = 1 if homework type = "O"; I(Homework type) = -1 if homework type = "P"
- I(native) = 1 if native = "N"; I(native) = -1 if native = "Y"
- I(nontraditional) = 1 if nontraditional = "N"; I(nontraditional) = -1 if nontraditional = "Y"
- I(course level1) = 1 if course level = "A"; I(course level1) = 0 if course level = "B" or "C"; I(course level1) = -1 if course level = "D"
- I(course level2) = 1 if course level = "B"; I(course level2) = 0 if course level = "A" or "C"; I(course level2) = -1 if course level = "D"
- I(course level3) = 1 if course level = "C"; I(course level3) = 0 if course level = "B" or "A"; I(course level3) = -1 if course level = "D"
- I(time of day) = 1 if time of day = "Afternoon"; I(time of day) = -1 if time of day = "morning"

- I(times per week) = 1 if times per week = “2”; I(times per week) = -1 if times per week = “3”

The fitted model could be used for the purpose of prediction, given the values of the independent variables. The assumptions of the models were checked. The skewness and kurtosis of the residuals from the fitted model were -0.443 and 3.298, respectively. Although the Shapiro-Wilk test rejected the null hypothesis that the residuals were from a normal distribution (p = 0.0102), the QQ plot (Figure 2) suggests that the residuals seemed to follow a normal distribution. The plot of residuals and fitted values (Figure 3) suggests the variances were homogeneous. Thus, the assumptions of the linear model were satisfied and hence the fitted model was adequate.

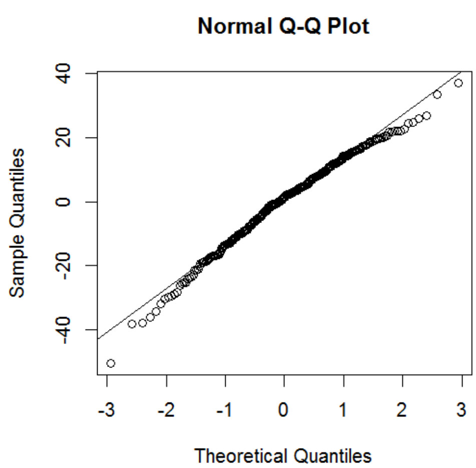


Figure 2: QQ plot, dependent variable = post-test

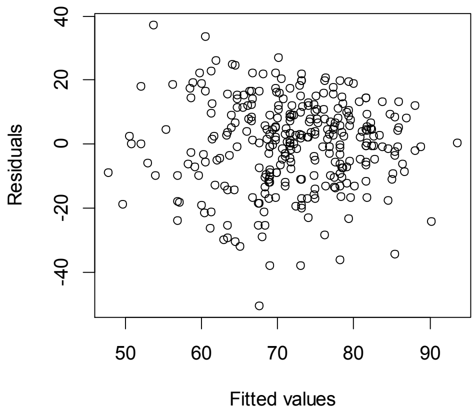


Figure 3: Plot of residuals and fitted values, dependent variable = post-test

Final Course Grade

Analysis for final course grade was done in SAS, Statistical Analysis System. The dependent variable, Final course grade, had 5 levels: A, B, C, D and F (note that U and W were not used in the data analysis). In the data analysis, the coding for final course grade is: 0 = F, 1 = D, 2 = C, 3 = B, 4 = A. Ordinal logistic regression (Proportional odds model) was first used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, final course grade. The score test for the proportional odds assumption suggests that the proportional odds assumption has been violated ($p <$ 0.0001).

Thus, the model was fit using multinomial logistic regression for investigating the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, final course grade. First, the results of the deviance and Pearson goodness-of-fit statistics were examined. The results based on deviance goodness-of-fit statistic suggest that model fit was fine (p = 1.000); however, the results based on Pearson goodness-of-fit statistic suggest that model fit was not fine (p = 0.0026). This suggested reconsidering the factors included in the model. As none of the interaction effects were statistical significant at the 0.05 level, in the next step of model fitting, only main effects were included in the model.

Next the model was fitted using multinomial logistic regression for investigating the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) on the dependent variable, final course grade. Both the deviance and Pearson goodness-of-fit statistics suggest that model fit was adequate (p = 0.9994 and 0.1297, respectively). The results of the type 3 analysis of effects based on the Wald χ^2 test suggest that:

- The effect of times per week was not statistically significant at the 0.05 level (χ^2 (4, N = 348) = 0.83, p = 0.9339).
- The effect of time of day was statistically significant at the 0.05 level (χ^2 (4, N = 348) = 10.94, p = 0.0273).
- The effect of course level was statistically significant at the 0.05 level (χ^2 (12, N = 348) = 30.71, p = 0.0022).

- The effect of non-traditional was statistically significant at the 0.05 level (χ^2 (4, N = 348) = 14.73, p = 0.0053).
- The effect of native was not statistically significant at the 0.05 level (χ^2 (4, N = 348) = 6.98, p = 0.1369).
- The effect of pre-test was statistically significant at the 0.05 level (χ^2(4, N = 348) = 15.66, p = 0.0035).
- The effect of homework type was not statistically significant at the 0.05 level (χ^2 (4, N = 348) = 6.69, p = 0.1532).

Pass Rate

As pass rate was a categorical variable with two levels (0 = fail, 1 = pass), multiple logistic regression was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, pass rate.

The results of the type 3 analysis of effects based on the Wald χ^2 test were used to determine which effect was statistically significant, i.e., if there was a relationship between the dependent variable and the independent variable. None of the interaction effects were statistically significant at the 0.05 level:

- The interaction effect of homework type and times per week was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 2.01, p = 0.1565).

- The interaction effect of homework type and time of day was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 1.22, p = 0.2689).
- The interaction effect of homework type and course level was not statistically significant at the 0.05 level (χ^2 (3, N = 382) = 5.19, p = 0.1582).
- The interaction effect of homework type and non-traditional was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 3.24, p = 0.0717).
- The interaction effect of homework type and native was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.37, p = 0.5414).
- The interaction effect of homework type and pre-test was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.08, p = 0.7748).

As none of the interaction effects were statistically significant, they were removed from the model and a multiple logistic regression was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) on the dependent variable, pass rate.The results of the type 3 analysis of effects based on the Wald χ^2 test suggest that:

- The effect of times per week was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 1.48, p = 0.223).
- The effect of time of day was statistically significant at the 0.05 level (χ^2 (1, N = 382) = 4.07, p = 0.044).

- The effect of course level was statistically significant at the 0.05 level (χ^2 (3, N = 382) = 23.39, $p < 0.0001$).
- The effect of non-traditional was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.87, p = 0.351).
- The effect of native was statistically significant at the 0.05 level (χ^2 (1, N = 382) = 5.07, p = 0.024).
- The effect of pre-test was (borderline) statistically significant at the 0.05 level (χ^2 (1, N = 382) = 3.87, p = 0.049).
- The effect of homework type was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.23, p = 0.633).

The Hosmer-Lemeshow goodness-of-fit tests suggest that the fitted model was adequate (χ^2 (8, N = 382) = 10.45, p = 0.2348). Based on the results of parameter estimation, the fitted model could be written as:

Logit(P(pass = 1)) = log(P(pass = 1)/(1-P(pass = 1)))= -0.48 – 0.11*I(Homework type) + 0.01*Pretest + 0.61*I(native) - 0.21*I(nontraditional) + 0.30*I(course level1) – 0.67*I(course level2) + 0.79*I(course level3) - 0.47*I(Time of day) – 0.32*I (Times per week) where, based on dummy coding,

- I(Homework type) = 1 if homework type = “O”; I(Homework type) = 0 if homework type = “P”
- I(native) = 1 if native = “N”; I(native) = 0 if native = “Y”

- I(nontraditional) = 1 if nontraditional = “N”; I(nontraditional) = 0 if nontraditional = “Y”
- I(course level1) = 1 if course level = “A”; else, I(course level1) = 0
- I(course level2) = 1 if course level = “B”; else, I(course level2) = 0
- I(course level3) = 1 if course level = “C”; else, I(course level3) = 0
- I(time of day) = 1 if time of day = “Afternoon”; I(time of day) = 0 if time of day = “morning”
- I(times per week) = 1 if times per week = “2”; I(times per week) = 0 if times per week = “3”

The fitted model could also be used to derive the probability of pass (pass = 1) given the independent variables, Homework type, Pre-test, course level, Times per week, Time of day, Native, and Non-traditional. For example, the probability of pass, when homework type = “P”, native = “Y”, nontraditional = “Y”, course level = “C”, time of day = “morning”, times per week = “3”, and pretest = 90 is exp(-0.48 + 0.01*90 + 0.79)/(1+ exp(-0.48 + 0.01*90 + 0.79)) = 0.7703.

Research Question Two: Persistence

To what extent does online homework affect the persistence of students enrolled in developmental mathematics courses, as measured by attendance and withdrawal rates?

Attendance

In this section, ANOVA was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, attendance. Figure 4 shows the histogram plot of attendance. It seems the data are skewed to the left.

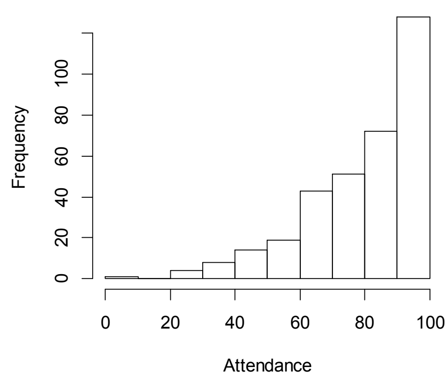


Figure 4: Histogram plot of attendance.

Before discussing the analysis results, the model assumptions were first examined. The skewness and kurtosis of the residuals from the fitted model were -1.012 and 4.191, respectively. The Shapiro-Wilk test rejected the null hypothesis that the residuals were from a normal distribution (p < 0.0001), and the QQ plot (Figure 5) suggests that the residuals deviated from a normal distribution. The plot of residuals and fitted values (Figure 6) suggests the variances were homogeneous. Thus, analysis preceded with arcsine square root transformation for Attendance/100, as recommended by Kutner, Nachtsheim, Neter and Li (2005) for proportions from count data.

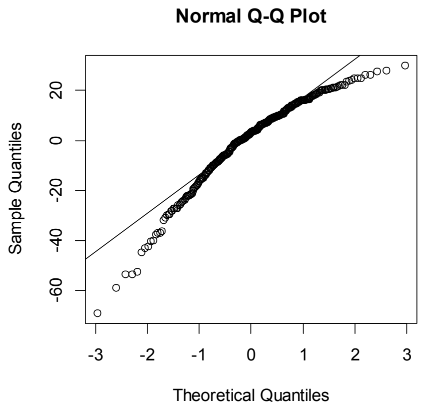


Figure 5: QQ plot, dependent variable = attendance

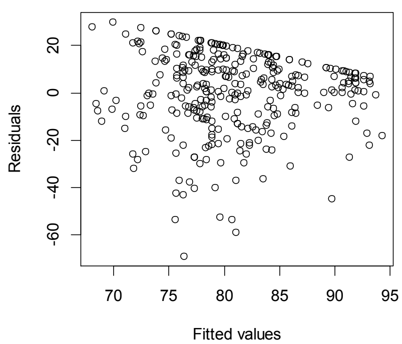


Figure 6: Plot of residuals and fitted values, dependent variable = attendance

Figure 7 shows the histogram plot of the transformed variable, arcsin($\sqrt{\text{Attendance}/100}$).

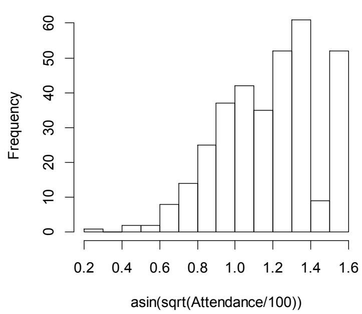


Figure 7: Histogram plot of arcsin($\sqrt{\text{Attendance}/100}$).

ANOVA was then used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, arcsin($\sqrt{\text{Attendance}/100}$). For the interaction effects, the results of the F test indicate that:

- The interaction effect of homework type and times per week was not statistically significant at the 0.05 level (F (1, 300) = 0.93, p = 0.3358).
- The interaction effect of homework type and time of day was not statistically significant at the 0.05 level (F (1, 300) = 3.42, p = 0.0653).
- The interaction effect of homework type and course level was not statistically at the 0.05 level (F (3, 300) = 1.10, p = 0.3478).
- The interaction effect of homework type and non-traditional was not statistically at the 0.05 level (F (1, 300) = 0.58, p = 0.4467).
- The interaction effect of homework type and native was not statistically significant at the 0.05 level (F (1, 300) = 0.02, p = 0.8987).
- The interaction effect of homework type and pre-test was not statistically significant at the 0.05 level (F (1, 300) = 0.39, p = 0.5306).

For the main effect (only investigated if interaction effect was not statistically significant), the results of the F test indicate that:

- The effect of times per week was not statistically significant at the 0.05 level (F (1, 300) = 0.79, p = 0.3762).

- The effect of time of day was statistically significant at the 0.05 level (F (1, 300) = 8.81, p = 0.0032). The estimated marginal means of arcsin($\sqrt{\text{Attendance}/100}$) (standard error in parentheses) for time of day = "afternoon" and "morning" were: 1.23(0.03) and 1.10(0.04), respectively. There was a statistically significant difference on the means of arcsin($\sqrt{\text{Attendance}/100}$) between afternoon group and morning group. The estimated marginal means of attendance for time of day = "afternoon" and "morning" were 0.8883 = $(\sin(1.23))^2$ and 0.7943 = $(\sin(1.10))^2$, respectively.
- The effect of course level was statistically significant at the 0.05 level (F (3, 300) = 6.14, p = 0.0005). The estimated marginal means of arcsin($\sqrt{\text{Attendance}/100}$) (standard error in parentheses) for course level = A, B, C and D were: 1.08(0.04), 1.10(0.04), 1.15(0.03) and 1.34(0.05), respectively. Pairwise comparisons using Tukey-Kramer's method suggests that there was a statistically significant difference on the means of arcsin($\sqrt{\text{Attendance}/100}$) between course level = "D", and each of the other course levels (p < 0.05).
- The effect of non-traditional was not statistically significant at the 0.05 level (F (1, 300) = 0.30, p = 0.5834).
- The effect of native was statistically significant at the 0.05 level (F (1, 300) = 8.08, p = 0.0048). The estimated marginal means of arcsin($\sqrt{\text{Attendance}/100}$) (standard error in parentheses) for native = N and Y were: 1.22(0.02) and

1.11(0.04), respectively. There was a statistically significant difference on the means of $\arcsin(\sqrt{\mathrm{Attendance}/100})$ between native and non-native students.

- The effect of pre-test was not statistically significant at the 0.05 level (F (1, 300) = 0.40, p = 0.5293).
- The effect of homework type was not statistically significant at the 0.05 level (F (1, 300) = 0.12, p = 0.7257).

Based on the results of parameter estimation, the fitted model could be written as: $\arcsin(\sqrt{\mathrm{Attendance}/100})$ = -1.13 -0.02*I(Homework type) + 0.0006*Pretest +0.05*I(native)+ 0.008*I(nontraditional) – 0.09*I(course level1) – 0.07*I(course level2) –0.02*I(course level3) + 0.06*I(Time of day) + 0.02*I (Times per week) + 0.0006*I(Homeworktype)*Pretest -0.002*I(Homework type) *I(native) - 0.01*I(Homework type)*I(nontraditional) + 0.03*I(Homework type)*I(course level1)+ 0.06*I(Homework type)*I(course level2) – 0.02*I(Homework type)*I(course level3)- 0.04*I(Homework type)*I(time of day) + 0.02*I(Homework type)*I(times per week), where, based on dummy coding,

- I(Homework type) = 1 if homework type = “O”; I(Homework type) = -1 if homework type = “P”
- I(native) = 1 if native = “N”; I(native) = -1 if native = “Y”
- I(nontraditional) = 1 if nontraditional = “N”; I(nontraditional) = -1 if nontraditional = “Y”

- I(course level1) = 1 if course level = “A”; I(course level1) = 0 if course level = “B” or “C”; I(course level1) = -1 if course level = “D”
- I(course level2) = 1 if course level = “B”; I(course level2) = 0 if course level = “A” or “C”; I(course level2) = -1 if course level = “D”
- I(course level3) = 1 if course level = “C”; I(course level3) = 0 if course level = “B” or “A”; I(course level3) = -1 if course level = “D”
- I(time of day) = 1 if time of day = “Afternoon”; I(time of day) = -1 if time of day = “morning”
- I(times per week) = 1 if times per week = “2”; I(times per week) = -1 if times per week = “3”

The fitted model could be used for the purpose of prediction, given the values of the independent variables. Note that to transform back to the original scale, one can do $(\sin(\arcsin\left(\sqrt{\text{attendance}/100}\right)^2$.

The assumptions of the models were checked. The skewness and kurtosis of the residuals from the fitted model were -0.21 and 3.017, respectively. The Shapiro-Wilk test did not reject the null hypothesis that the residuals were from a normal distribution (p = 0.0647), and the QQ plot (Figure 8) suggests that the residuals seemed to follow a normal distribution. The plot of residuals and fitted values (Figure 9) suggests the variances were homogeneous. Thus the assumptions of the linear model were satisfied and hence the fitted model was adequate.

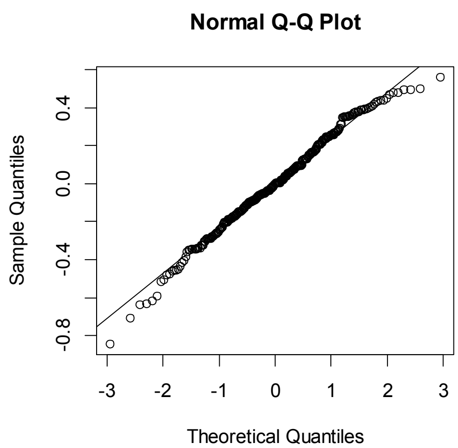


Figure 8: QQ plot, dependent variable = arcsin($\sqrt{\text{Attendance}/100}$).

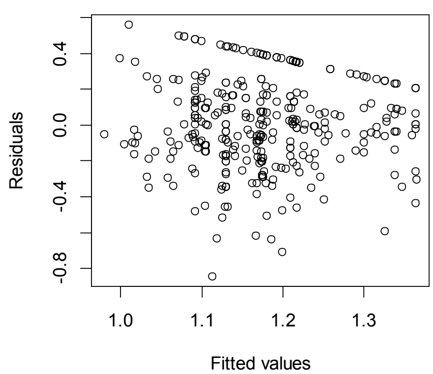


Figure 9: Plot of residuals and fitted values, arcsin($\sqrt{\text{Attendance}/100}$).

Withdrawal Rate

As withdrawal rate was a categorical variable with two levels (0 = not withdrawal, 1 = withdrawal), multiple logistic regression was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, withdrawal rate.

The results of the type 3 analysis of effects based on the Wald χ^2 test were used to determine which effect was statistically significant, i.e., if there was a relationship between the dependent variable and the independent variable. None of the interaction effects were statistically significant at the 0.05 level:

- The interaction effect of homework type and times per week was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.11, p = 0.741).
- The interaction effect of homework type and time of day was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.14, p = 0.704).
- The interaction effect of homework type and course level was not statistically significant at the 0.05 level (χ^2 (3, N = 382) = 3.12, p = 0.374).
- The interaction effect of homework type and non-traditional was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.00, p = 0.974).
- The interaction effect of homework type and native was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.32, p = 0.572).
- The interaction effect of homework type and pre-test was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 1.32, p = 0.250).

As none of the interaction effects were statistically significant, they were removed from the model and a multiple logistic regression was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) on the dependent variable, withdrawal rate. The results of the type 3 analysis of effects based on the Wald χ^2 test suggest that:

- The effect of times per week was statistically significant at the 0.05 level (χ^2 (1, N = 382) = 8.84, p = 0.0029).
- The effect of time of day was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.03, p = 0.8562).
- The effect of course level was statistically significant at the 0.05 level (χ^2 (3, N = 382) = 9.37, p = 0.0247).
- The effect of non-traditional was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.27, p = 0.6058).
- The effect of native was statistically significant at the 0.05 level (χ^2 (1, N = 382) = 6.13, p = 0.0133).
- The effect of pre-test was not statistically significant at the 0.05 level (χ^2(1, N = 382) = 2.29, p = 0.1302).
- The effect of homework type was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 1.01, p = 0.3158).

The Hosmer-Lemeshow goodness-of-fit tests suggest that the fitted model was adequate (χ^2 (8, N = 382) = 2.981, p = 0.9355). Based on the results of parameter estimation, the fitted model could be written as:

Logit(P(withdrawal = 1)) = log(P(withdrawal = 1)/(1-P(withdrawal = 1)))= -0.59 +0.43*I(Homework type) - 0.02*Pretest – 1.07*I(native) + 0.20*I(nontraditional) – 1.82*I(course level1) – 0.27*I(course level2) – 1.21*I(course level3) - 0.07*I(Time of day) +1.31*I (Times per week) where, based on dummy coding,

- I(Homework type) = 1 if homework type = “O”; I(Homework type) = 0 if homework type = “P”
- I(native) = 1 if native = “N”; I(native) = 0 if native = “Y”
- I(nontraditional) = 1 if nontraditional = “N”; I(nontraditional) = 0 if nontraditional = “Y”
- I(course level1) = 1 if course level = “A”; else, I(course level1) = 0
- I(course level2) = 1 if course level = “B”; else, I(course level2) = 0
- I(course level3) = 1 if course level = “C”; else, I(course level3) = 0
- I(time of day) = 1 if time of day = “Afternoon”; I(time of day) = 0 if time of day = “morning”
- I(times per week) = 1 if times per week = “2”; I(times per week) = 0 if times per week = “3”

The fitted model could also be used to derive the probability of withdrawal (withdrawal = 1) given the independent variables, Homework type, Pre-test, course level, Times per week, Time of day, Native, and Non-traditional. For example, the probability of withdrawal, when homework type = “P”, native = “Y”, nontraditional = “Y”, course level = “C”, time of day = “morning”, times per week = “3”, and pretest = 90 is exp(-0.59 - 0.02*90 - 1.21)/(1+ exp(-0.59 -0.02*90 -1.21)) = 0.02.

Research Question Three: Attitude

To what extent does online homework affect the attitudes of students enrolled in developmental mathematics courses, as measured with the Fennema-Sherman Mathematical Confidence and Mathematical Usefulness Scales, and homework questionnaires?

Change in Attitude of Confidence

ANOVA was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, changes in attitude of confidence in math. Figure 10 shows the histogram plot of the dependent variable, changes in attitude of confidence in math.

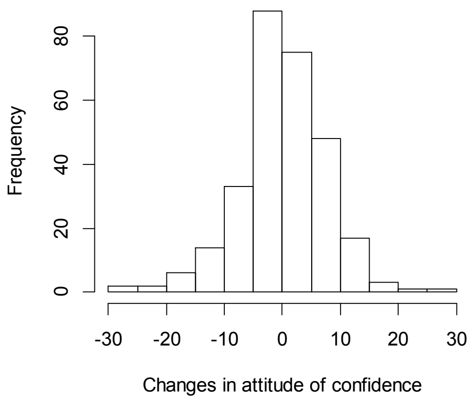


Figure 10: Histogram of the dependent variable, changes in attitude of confidence in math

For the interaction effects, the results of the F test indicate that:

- The interaction effect of homework type and times per week was not statistically significant at the 0.05 level (F (1, 268) = 2.59, p = 0.109).
- The interaction effect of homework type and time of day was not statistically significant at the 0.05 level (F (1, 268) = 0.43, p = 0.514).
- The interaction effect of homework type and course level was not statistically significant at the 0.05 level (F (3, 268) = 0.77, p = 0.512).
- The interaction effect of homework type and non-traditional was not statistically significant at the 0.05 level (F (1, 268) = 0.85, p = 0.358).
- The interaction effect of homework type and native was not statistically significant at the 0.05 level (F (1, 268) = 1.05, p = 0.306).
- The interaction effect of homework type and pre-test was not statistically significant at the 0.05 level (F (1, 268) = 0.94, p = 0.333).

For the main effect (only investigated if interaction effect was not statistically significant), the results of the F test indicate that:

- The effect of times per week was not statistically significant at the 0.05 level (F (1, 268) = 1.20, p = 0.274).
- The effect of time of day was (borderline) statistically significant at the 0.05 level (F (1, 268) = 3.85, p = 0.051). The estimated marginal means of changes in attitude of usefulness of math (standard error in parentheses) for time of day = "afternoon" and "morning" were: -0.80(0.91) and 1.37(0.91), respectively. There was a statistically significant difference on the means of changes in attitude of confidence in math between afternoon group and morning group.
- The effect of course level was not statistically significant at the 0.05 level (F (3, 268) = 2.50, p = 0.060).
- The effect of non-traditional was not statistically significant at the 0.05 level (F (1, 268) = 0.07, p = 0.785).
- The effect of native was not statistically significant at the 0.05 level (F (1, 268) = 1.29, p = 0.257).
- The effect of pre-test was not statistically significant at the 0.05 level (F (1, 268) = 2.78, p = 0.096).
- The effect of homework type was not statistically significant at the 0.05 level (F (1, 268) = 0.68, p = 0.411).

Based on the results of parameter estimation, the fitted model could be written as: changes in attitude of confidence in math = -5.49 + 3.22*I(Homework type) + 0.04*Pretest +0.69*I(native) - 0.49*I(nontraditional) + 1.87*I(course level1) – 0.13*I(course level2) –0.52*I(course level3) - 0.75*I(Time of day) – 1.97*I (Times per week) - 0.04*I(Homework type)*Pretest -1.05*I(Homework type) *I(native) - 0.59*I(Homework type)*I(nontraditional) –1.59*I(Homework type)*I(course level1) – 0.58*I(Homework type)*I(course level2) +0.10*I(Homework type)*I(course level3) + 0.72*I(Homework type)*I(time of day) +1.10*I(Homework type)*I(times per week), where, based on dummy coding,

- I(Homework type) = 1 if homework type = “O”; I(Homework type) = -1 if homework type = “P”
- I(native) = 1 if native = “N”; I(native) = -1 if native = “Y”
- I(nontraditional) = 1 if nontraditional = “N”; I(nontraditional) = -1 if nontraditional = “Y”
- I(course level1) = 1 if course level = “A”; I(course level1) = 0 if course level = “B” or “C”; I(course level1) = -1 if course level = “D”
- I(course level2) = 1 if course level = “B”; I(course level2) = 0 if course level = “A” or “C”; I(course level2) = -1 if course level = “D”
- I(course level3) = 1 if course level = “C”; I(course level3) = 0 if course level = “B” or “A”; I(course level3) = -1 if course level = “D”
- I(time of day) = 1 if time of day = “Afternoon”; I(time of day) = -1 if time of day = “morning”

- I(times per week) = 1 if times per week = “2”; I(times per week) = -1 if times per week = “3”

The fitted model could be used for the purpose of prediction, given the values of the independent variables. The assumptions of the models were checked. The skewness and kurtosis of the residuals from the fitted model were -0.064 and 3.937, respectively. The Shapiro-Wilk test did not reject the null hypothesis that the residuals were from a normal distribution (p = 0.112), and the QQ plot (Figure 11) suggests that the residuals seemed to follow a normal distribution. The plot of residuals and fitted values (Figure 12) suggests the variances were homogeneous. Thus the assumptions of the linear model were satisfied and hence the fitted model was adequate.

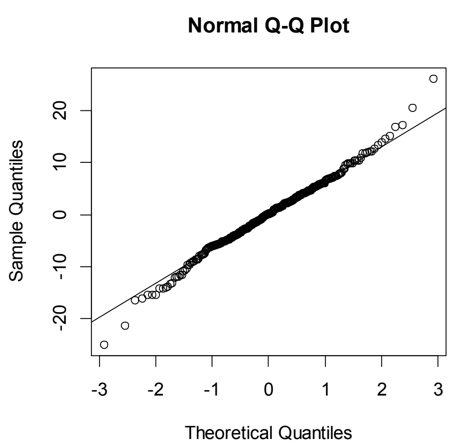


Figure 11: QQ plot, dependent variable = changes in attitude of confidence in math.

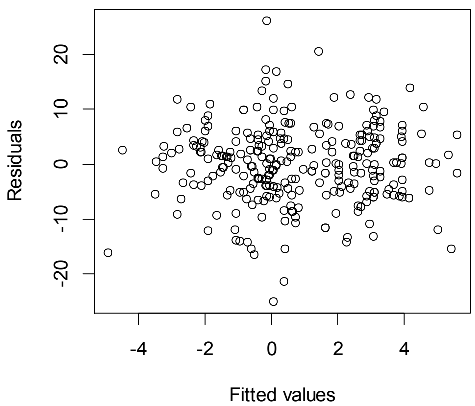


Figure 12: Plot of residuals and fitted values, dependent variable = changes in attitude of confidence in math.

Figure 13 shows the histogram plot of the dependent variable, changes in attitude of usefulness of math.

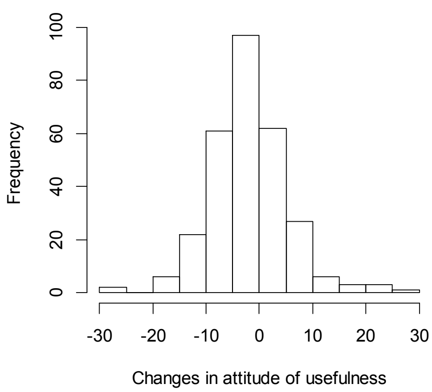


Figure 13: Histogram of the dependent variable, changes in attitude of usefulness of math

Change in Attitude of Usefulness of Mathematics

ANOVA was used to investigate the main effects of the independent variables (Homework type, Pre-test, course level, Times per week, Time of day, Native, Non-traditional) and the interaction effect of homework type and all the other variables on the dependent variable, changes in attitude of usefulness of math. For the interaction effects, the results of the F test indicate that:

- The interaction effect of homework type and times per week was not statistically significant at the 0.05 level ($F(1, 268) = 2.80$, $p = 0.0957$).
- The interaction effect of homework type and time of day was not statistically significant at the 0.05 level ($F(1, 268) = 1.65$, $p = 0.2002$).
- The interaction effect of homework type and course level was not statistically significant at the 0.05 level ($F(3, 268) = 1.26$, $p = 0.2878$).
- The interaction effect of homework type and non-traditional was not statistically significant at the 0.05 level ($F(1, 268) = 1.71$, $p = 0.1917$).
- The interaction effect of homework type and native was not statistically significant at the 0.05 level ($F(1, 268) = 3.64$, $p = 0.0642$).
- The interaction effect of homework type and pre-test was not statistically significant at the 0.05 level ($F(1, 268) = 1.25$, $p = 0.2647$).

For the main effect (only investigated if interaction effect was not statistically significant), the results of the F test indicate that:

- The effect of times per week was statistically significant at the 0.05 level (F (1, 268) = 8.94, p = 0.0031). The estimated marginal means of changes in attitude of usefulness of math (standard error in parentheses) for times per week = "2" and "3" were: -5.01(1.22) and -1.08(0.67), respectively. There was a statistically significant difference on the means of changes in attitude of usefulness of math between times per week = 2 and 3.
- The effect of time of day was not statistically significant at the 0.05 level (F (1, 268) = 1.81, p = 0.1790).
- The effect of course level was not statistically significant at the 0.05 level (F (3, 268) = 1.15, p = 0.3288).
- The effect of non-traditional was not statistically significant at the 0.05 level (F (1, 268) = 1.20, p = 0.2749).
- The effect of native was statistically significant at the 0.05 level (F (1, 268) = 8.08, p = 0.0048).
- The effect of pre-test was not statistically significant at the 0.05 level (F (1, 268) = 0.40, p = 0.5293).
- The effect of homework type was not statistically significant at the 0.05 level (F (1, 268) = 0.12, p = 0.7257).

Based on the results of parameter estimation, the fitted model could be written as: changes in attitude of usefulness of math = -5.49 + 3.22*I(Homework type) + 0.04*Pretest + 0.69*I(native) - 0.49*I(nontraditional) + 1.87*I(course level1) –

0.13*I(course level2) – 0.52*I(course level3) - 0.75*I(Time of day) – 1.97*I (Times per week) - 0.04*I(Homework type)*Pretest -1.05*I(Homework type) *I(native) - 0.59*I(Homework type)*I(nontraditional) – 1.59*I(Homework type)*I(course level1) – 0.58*I(Homework type)*I(course level2) + 0.10*I(Homework type)*I(course level3) + 0.72*I(Homework type)*I(time of day) + 1.10*I(Homework type)*I(times per week), where, based on effect coding,

- I(Homework type) = 1 if homework type = "O"; I(Homework type) = -1 if homework type = "P"
- I(native) = 1 if native = "N"; I(native) = -1 if native = "Y"
- I(nontraditional) = 1 if nontraditional = "N"; I(nontraditional) = -1 if nontraditional = "Y"
- I(course level1) = 1 if course level = "A"; I(course level1) = 0 if course level = "B" or "C"; I(course level1) = -1 if course level = "D"
- I(course level2) = 1 if course level = "B"; I(course level2) = 0 if course level = "A" or "C"; I(course level2) = -1 if course level = "D"
- I(course level3) = 1 if course level = "C"; I(course level3) = 0 if course level = "B" or "A"; I(course level3) = -1 if course level = "D"
- I(time of day) = 1 if time of day = "Afternoon"; I(time of day) = -1 if time of day = "morning"
- I(times per week) = 1 if times per week = "2"; I(times per week) = -1 if times per week = "3"

The fitted model could be used for the purpose of prediction, given the values of the independent variables. The assumptions of the models were checked. The skewness and kurtosis of the residuals from the fitted model were 0.230 and 5.184, respectively. The Shapiro-Wilk test rejected the null hypothesis that the residuals were from a normal distribution ($p < 0.0001$), but the QQ plot (Figure 14) suggests that the residuals seemed to follow a normal distribution for the most part. The plot of residuals and fitted values (Figure 15) suggests the variances were homogeneous. Thus, the assumptions of the linear model were satisfied and hence the fitted model was adequate.

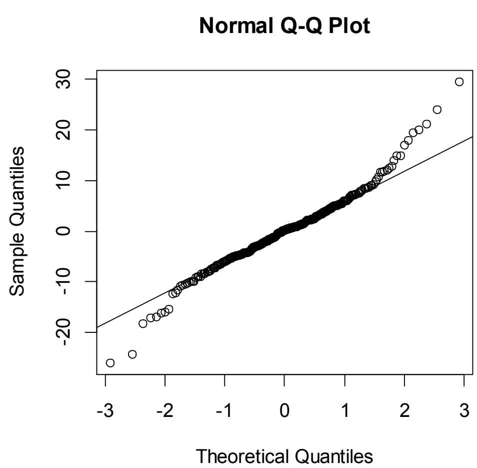


Figure 14: QQ plot, dependent variable = changes in attitude of usefulness of math

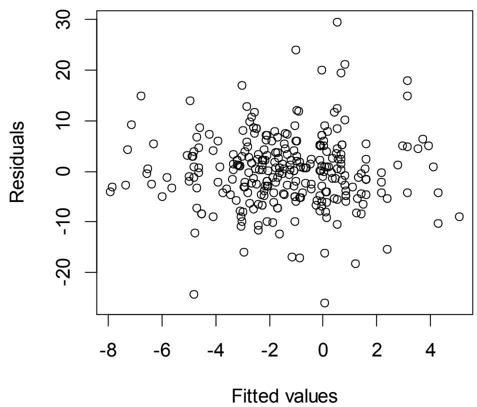


Figure 15: Plot of residuals and fitted values, dependent variable = changes in attitude of usefulness of math

Homework Questionnaires

Student and instructor homework questionnaires were administered during the last week of the semester (see appendices J and K). The directions were to rank the five statements on how much you agree with the statement given. The scale was 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree. Table 9 summarizes the mean responses of all students who used online homework, all those who used paper homework, and the p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups. The Wilcoxon Rank-Sum Test was used to determine if the two samples differ in the mean ranks, while making no assumptions about the distribution of the data.

Table 9: Wilcoxon Test Results on Post Questionnaire: Comparison of Online to Paper Homework: All Students

Statement	Mean online HW response	Mean paper HW response	Difference	P-value
1	4.175	4.421	-0.246	0.01352*
2	3.950	4.179	-0.229	0.06447
3	4.244	4.359	-0.115	0.325
4	4.176	4.347	-0.171	0.1118
5	3.906	4.500	-0.594	<.001*

*Statistically significant at 0.05 level

Instructors were given similar questions and their response means are compared to students' responses. Table 10 summarizes the mean responses of students and instructors, and p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups.

Table 10: Wilcoxon Test Results on Post Questionnaire: Comparison of Students and Instructors: All Students

Student Statement (group)	Instructor Statement	Mean instructor response	Mean student response	Difference	P-value
1 (online)	1	4.667	4.175	+0.492	0.1205
1 (paper)	2	4.000	4.421	-0.421	0.3353
2 (online)	4	4.167	3.950	+0.217	0.7481
2 (paper)	5	4.000	4.179	-0.179	0.4072
3 (online)	6	3.667	4.244	-0.577	0.0332*
3 (paper)	7	3.500	4.359	-0.859	0.0231*
4 (online)	8	4.833	4.176	+0.657	0.0368*
4 (paper)	8	4.833	4.347	+0.486	0.0773
5 (online)	9	4.000	3.906	+0.094	0.8296
5 (paper)	10	3.167	4.500	-1.333	0.0043*

*Statistically significant at 0.05 level

Alaskan Native Students

Achievement was measured by post-test, final course grade and pass rates. The interaction effect of homework type and native status on post-test was not significant at the 0.05 level (F (1, 284) = 1.26, p = 0.2625). The main effect of native status on post-test was statistically significant at the 0.05 level (F (1, 284) = 17.54, $p < 0.0001$). There was a statistically significant difference on the means of post-test between native and non-native students. The estimated marginal means of post-test (standard error in parentheses) for non-native was 72.65(1.16) and native was 63.74(2.15). Native status did not have a significant main effect on final course grade at the 0.05 level (χ^2 (4, N = 348) = 6.98, p = 0.1369). The interaction effect of homework type and native status did not have a significant effect on pass rate at the 0.05 level (χ^2 (1, N = 382) = 0.37, p = 0.5414). The main effect of native status on pass rate was statistically significant at the 0.05 level (χ^2 (1, N = 382) = 5.07, p = 0.024).

Persistence was measured by attendance and withdrawal rate. Attendance did not have a significant interaction effect from homework type and native status at the 0.05 level (F (1, 300) = 0.02, p = 0.8987). The main effect of native status on persistence was statistically significant at the 0.05 level (F (1, 300) = 8.08, p = 0.0048). The estimated marginal means of attendance (standard error in parentheses) for non-native was 0.88(0.003) and native was .80(0.002). Withdrawal rate did not have a significant interaction effect from homework type and native status at the 0.05 level (χ^2 (1, N = 382) = 0.32, p = 0.572). The main effect of native status on withdrawal rate was statistically significant at the 0.05 level (χ^2 (1, N = 382) = 6.13, p = 0.0133).

Attitude was measured by change in attitude of confidence, change in attitude of mathematical usefulness, and by homework questionnaire. Change in attitude of confidence did not have a significant interaction effect from homework type and native status at the 0.05 level (F (1, 268) = 1.05, p = 0.306). The main effect of native status on change in attitude of confidence was not statistically significant at the 0.05 level (F (1, 268) = 1.29, p = 0.257). Change in attitude of mathematical usefulness did not have a significant interaction effect from the interaction effect of homework type and native status at the 0.05 level (F (1, 268) = 3.64, p = 0.0642). The main effect of native status on change in attitude of usefulness was not statistically significant at the 0.05 level (F (1, 268) = 8.08, p = 0.0048).

The analysis of the homework questionnaire was comparative in nature. Table 11 summarizes the mean responses of Alaska Native students who used online homework, Alaska Native Students who used paper homework, and the p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups.

Table 11: Wilcoxon Test Results on Post Questionnaire: Comparison of Online to Paper Homework: Alaska Native Students

Statement	Mean online HW response (Native only)	Mean paper HW response (Native only)	Difference	P-value
1	4.133	4.286	-0.153	0.7976
2	3.667	3.964	-0.297	0.3836
3	3.900	4.107	-0.207	0.831
4	4.100	4.185	-0.085	0.8442
5	4.000	4.393	-0.393	0.2143

Table 12 summarizes the mean responses of Alaska Native students who used online homework, non- Alaska Native Students who used online homework, and the p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups.

Table 12: Wilcoxon Test Results on Post Questionnaire: Comparison of Alaska Native to Non-Native Students: Online HW

Statement	Mean online HW Native Response	Mean online HW Non-Native Response	Difference	P-value
1	4.133	4.198	-0.065	0.7407
2	3.667	4.017	-0.350	0.09283
3	3.900	4.331	-0.431	0.01979*
4	4.100	4.192	-0.092	0.3571
5	4.000	3.893	+0.107	0.9783

*Statistically significant at 0.05 level

Table 13 summarizes the mean responses of Alaska Native students who used paper homework, non- Alaska Native Students who used paper homework, and the p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups.

Table 13: Wilcoxon Test Results on Post Questionnaire: Comparison of Alaska Native to Non-Native Students: Paper HW

Statement	Mean paper HW Native Response	Mean paper HW Non-Native Response	Difference	P-value
1	4.286	4.464	-0.178	0.05112
2	3.964	4.227	-0.263	0.0504
3	4.107	4.445	-0.338	0.0005*
4	4.185	4.400	-0.215	0.03377*
5	4.393	4.578	-0.185	0.05243

*Statistically significant at 0.05 level

Non-Traditional Students

Achievement was measured by post-test, final course grade, and pass rates. Post-test did not have a significant interaction effect from homework type and non-traditional status at the 0.05 level (F (1, 284) = 0.02, p = 0.8969). The main effect of non-traditional was statistically significant at the 0.05 level (F (1, 284) = 8.41, p = 0.0040). The estimated marginal means of post-test (standard error in parentheses) for traditional students was 65.76(1.56) and for non-traditional was 70.63(1.65). There was a statistically significant difference on the means of post-test between traditional and non-traditional groups. Final course grade did have a significant main effect from non-traditional status at the 0.05 level (χ^2 (4, N = 348) = 14.73, p = 0.0053). The pass rate did not have a significant interaction effect from homework type and non-traditional status at the 0.05 level (χ^2 (1, N = 382) = 3.24, p = 0.0717). The main effect of non-traditional status on pass rate was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.87, p = 0.351).

Persistence was measured by attendance and withdrawal rate. Attendance did not have a significant interaction effect from homework type and non-traditional status at the 0.05 level (F (1, 300) = 0.58, p = 0.4467). The main effect of non-traditional status was not statistically significant at the 0.05 level (F (1, 300) = 0.30, p = 0.5834). Withdrawal rate did not have a significant interaction effect from homework type and non-traditional status at the 0.05 level (χ^2 (1, N = 382) = 0.00, p = 0.974). The main effect of non-traditional status was not statistically significant at the 0.05 level (χ^2 (1, N = 382) = 0.27, p = 0.6058).

Attitude was measured by change in attitude of confidence, changs in attitude of mathematical usefulness, and by homework questionnaire. Change in attitude of confidence did not have a significant interaction effect from homework type and non-traditional status at the 0.05 level (F (1, 268) = 0.85, p = 0.358). The main effect of non-traditional status on change in attitude of confidence was not statistically significant at the 0.05 level (F (1, 268) = 0.07, p = 0.785). Change in attitude of mathematical usefulness did not have a significant interaction effect from the interaction effect of homework type and non-traditional status at the 0.05 level (F (1, 268) = 1.71, p = 0.1917). The main effect of non-traditional status on change in attitude of usefulness was not statistically significant at the 0.05 level (F (1, 268) = 1.20, p = 0.2749).

The analysis of the homework questionnaire was comparative in nature. Table 14 summarizes the mean responses of non-traditional students who used online homework, non-traditional students who used paper homework, and the p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups.

Table 14: Wilcoxon Test Results on Post Questionnaire: Comparison of Online to Paper Homework: Non Traditional Students

Statement	**Mean online HW response (Non-traditional only)**	**Mean paper HW response (Non-traditional only)**	**Difference**	**P-value**
1	4.291	4.525	-0.234	0.0728
2	3.958	4.339	-0.381	0.0167*
3	4.431	4.407	+0.024	0.8556
4	4.296	4.458	-0.162	0.191
5	4.111	4.603	-0.492	0.0079*

*Statistically significant at 0.05 level

Table 15 summarizes the mean responses of non-traditional students who used online homework, traditional students who used online homework, and the p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups.

Table 15: Wilcoxon Test Results on Post Questionnaire: Comparison of Non-Traditional to Traditional Students: Online HW

Statement	Mean online HW Non-Traditional Response	Mean online HW Traditional Response	Difference	P-value
1	4.292	4.100	+0.192	0.1753
2	3.958	3.050	+0.908	0.9812
3	4.431	4.088	+0.343	0.1492
4	4.296	4.075	+0.221	0.1588
5	4.111	3.750	+0.361	0.1228

Table 16 summarizes the mean responses of non-traditional students who used paper homework, traditional students who used paper homework, and the p-values from the Wilcoxon Rank-Sum Test for comparing distribution of two different groups.

Table 16: Wilcoxon Test Results on Post Questionnaire: Comparison of Non-Traditional to Traditional Students: Paper HW

Statement	Mean paper HW Non-Traditional Response	Mean paper HW Traditional Response	Difference	P-value
1	4.525	4.354	+0.171	0.1766
2	4.339	4.051	+0.288	0.01969*
3	4.407	4.367	+0.011	0.845
4	4.458	4.282	+0.276	0.0927
5	4.603	4.481	+0.122	0.5934

*Statistically significant at 0.05 level

Table 17 is a summary of the significant findings of analysis of the interactions between homework type and each of the covariates.

Table 17: P-Values of Statistical Significance of Interaction of HW type and Covariates on Dependent Variables

	Achievement			**Persistence**		**Attitude**	
HW type interaction with:	Post-test	final course grade	pass rate	attendance	withdrawal rate	change in confidence	change in usefulness
Pre-test	0.356	0.342	0.775	0.531	0.250	0.333	0.265
Course level	0.005*	0.060	0.158	0.348	0.374	0.512	0.288
Times per week	0.913	0.267	0.157	0.336	0.741	0.109	0.096
Time of day	0.112	0.109	0.269	0.065	0.704	0.514	0.200
Native	0.263	0.336	0.541	0.899	0.572	0.306	0.064
Non-traditional	0.897	0.062	0.072	0.447	0.974	0.358	0.192

*Statistically significant at 0.05 level

There was only one statistically significant interaction. The interaction between course level and homework type and its effect on post-test was the only significant interaction. Further analysis of the interaction effect shows that with online homework there is a statistical difference in post-test scores on course level B (beginning algebra).

Table 18 is a summary of the significant findings of the analysis of the main effects on each of the dependent variables. Main effects are considered only if the interaction effect is not statistically significant, hence the n/a on the effect of homework type and course level on post-test.

Table 18: P-Values of Statistical Significance of Main Effects on Dependent Variables
(only if interaction effect was not significant)

	Achievement			Persistence		Attitude	
Main Effect:	Post-test	final course grade	pass rate	attendance	withdrawal rate	change in confidence	change in usefulness
HW type	n/a	0.153	0.633	0.726	0.316	0.411	0.726
Pre-test	<0.0001*	0.004*	0.049*	0.529	0.130	0.096	0.529
Course level	n/a	0.002*	<0.0001*	0.0005*	0.025*	0.060	0.329
Times per week	0.102	0.934	0.223	0.3762	0.003*	0.274	0.003*
Time of day	0.945	0.273	0.044*	0.003*	0.856	0.051*	0.179
Native	<0.0001*	0.137	0.024*	0.0048*	0.013*	0.257	0.0048*
Non-traditional	0.004*	0.005*	0.351	0.583	0.606	0.785	0.275

*Statistically significant at 0.05 level

The main effect of homework type was not statistically significant on any of the dependent variables. The other of the main effects are peripheral to the current study, as each of the remaining main effects were not related to online homework. However, the statistical significance of the other main effects is included here as it may have bearing on future research.

Pre-test had a statistically significant effect on post-test, final course grade, and pass rate. Course level had a statistically significant effect on all the achievement and persistence measures, but not on the attitude measures. Times per week had a statistically significant effect on withdrawal rate and change in attitude in usefulness. Time of day had a statistically significant effect on pass rate, attendance, and change in confidence. Native had a statistically significant effect on post-test and pass rate, on both measures of persistence and change in usefulness. Non-traditional had a statistically significant effect on post-test and final course grade.

Table 19 is a summary of significant findings of the analysis of the questionnaire responses.

Table 19: P-Values of Statistical Significance from Questionnaire

	All Students			Alaska Native			Non-Traditional		
Statement	Paper vs. Online	Student vs. Instructor		Paper vs. Online	Native vs. Non-native		Paper vs. Online	Non-traditional vs. Traditional	
		Paper	Online		Paper	Online		Paper	Online
1	0.014* Paper	0.335	0.121	0.798	0.051	0.741	0.073	0.177	0.175
2	0.065	0.407	0.748	0.384	0.050	0.093	0.017* paper	0.020* nontrad	0.981
3	0.325	0.023* Student	0.033* Student	0.831	0.001* Nonnative	0.020* Nonnative	0.856	0.845	0.149
4	0.112	0.077	0.037* Instructor	0.844	0.034* Nonnative	0.357	0.191	0.093	0.159
5	<0.001* Paper	0.004* Student	0.830	0.214	0.052	0.978	0.008* paper	0.593	0.123

* Statistically significant at the 0.05 level. Group that felt stronger toward the statement is noted when a difference was statistically significant.

Summary

This chapter provided the results of the data analysis. Chapter Five will present the conclusion, discussion, and recommendations.

Chapter 5 Conclusions, Discussion, and Recommendations

Introduction

The purpose of the study is to analyze the effects of online homework on achievement, persistence, and attitude, with special focus on non-traditional and Alaska Native students. This chapter will present conclusions, discussion, and recommendations for further study.

Conclusions

Research Question 1: To what extent does online homework affect the achievement of students enrolled in developmental mathematics courses, as measured by a post-test, final course grade, and pass rates?

There was no significant main effect of homework type on final course grade or on the pass rate. However, the interaction effect of homework type and course level had a significant effect on post-test. This was the only interaction factor that had a significant effect on the three measures of achievement (post-test, final course grade, and pass rate). Upon further analysis, online homework has a positive effect on the post-test scores of beginning algebra. Online homework did not have a significant effect on the post-test scores of pre-algebra, intermediate algebra and intensive intermediate algebra.

Research Question 2: To what extent does online homework affect the persistence of students enrolled in developmental mathematics courses, as measured by attendance and withdrawal rates?

There were no significant main effect or interaction effects of homework type on the two measures of persistence (attendance and withdrawal rate).

Research Question 3: To what extent does online homework affect the attitudes of students enrolled in developmental mathematics courses, as measured with the Fennema-Sherman Mathematical Confidence and Mathematical Usefulness Scales, and homework questionnaires?

There were no significant main effect or interaction effects of homework type on the following of measures of attitude: change in confidence and change in usefulness. However, significant differences were found on the homework questionnaire. In general, the mean responses were very favorable for online homework: 4.09 (SD=1.00), but they were also favorable for paper homework: 4.36 (SD=0.78). On the statements “homework for this class helped me learn the material” and “I am satisfied with the homework format for this class” students in paper homework sections felt more favorable than the online homework sections. It is possible that students have a slightly more favorable overall attitude toward paper homework.

Analysis of online homework and Alaska Native students found no significant homework type/native status interaction effect on any of the dependent variables; which included measures of achievement (post-test, final course grade, pass rate,) persistence (attendance and withdrawal rate), and attitude (change in attitude and change in usefulness).

Alaska Native students demonstrated no significant differences between how they felt about online verses paper homework on the questionnaire. Non-native students in paper homework sections more strongly agreed with the following statements than Native students: “I did my homework most of the time” and “I believe doing homework is valuable.” Non-native students in online homework sections more strongly agreed with the following statement than Native students: “I did my homework most of the time”. Non-Native students scored all the statements higher than Native students for either type of homework.

Analysis of online homework and non-traditional students found no significant homework type/ non-traditional interaction effect on any of the dependent variables; which included measures of achievement (post-test, final course grade, pass rate), persistence (attendance and withdrawal rate), and attitude (change in attitude and change in usefulness).

Non-traditional students demonstrated more favorable opinions about paper homework than online homework on two measures of attitude. Non-traditional students in paper homework sections more strongly agreed with the following statements than non-traditional students in online homework sections: “The homework for this class helped my final grade in this course” and “I am satisfied with the homework format for this class”. Non-traditional students in paper homework sections more strongly agreed with the following statement than traditional students: “The homework for this class helped my final grade in this class”. This could be summarized as non-traditional students have a slightly more favorable overall attitude toward paper homework. Non-traditional students scored all the statements higher than traditional students for either type of homework.

Discussion

It is not uncommon for students to express their positive or negative opinions about online homework. As a developmental mathematics educator, this motivated the researcher to investigate the efficacy of homework type.

This study found that overall online homework does not produce a significant difference in achievement and persistence. The one exception was post-test scores of beginning algebra students using online homework were statistically higher than those using paper homework. Four out of nineteen sections involved were beginning algebra and two instructors taught these sections. It is possible that the instructors for these sections did have an influence on the improved achievement. But since the instructor factor caused multicollinearity, it was impossible to look at the effects of this factor. One of the beginning algebra instructors reported that students this semester were an unusually low performing (both the online and paper groups). This may have skewed the data and results. Or it is possible that the topics taught in beginning algebra lend themselves more towards the right/ wrong feedback given by online homework. But if that was the case, one might expect it to be true for pre-algebra also. It is very interesting that beginning algebra was the only course level that did not give written feedback in the form of quizzes. The beginning algebra courses utilized online homework, paper exams, and paper final exams.

In this study instructors scored online homework higher than paper homework on all five homework questionnaire statements. Statistical significance cannot be determined with a sample size of only six instructors. However, all of the instructors indicated they plan to continue using online homework in much the same manner as they did for this study. It is possible that the convenience and time-saving of not grading paper homework has a positive influence on instructor opinions.

Students scored online homework *lower* than paper homework on all five statements. Two differences were statistically significant. In general, this could indicate that when all students are surveyed there is a preference for paper homework. But online homework did not receive low scores. In fact, the scores were high on both paper and online homework (ranging from 3.9 to 4.2 for online homework and from 4.2 to 4.5 for online homework).

When comparing students' answers to instructors' answers an interesting trend is seen. For the paper group, *students* felt more strongly than instructors on the majority of statements. But with the online group, *instructors* felt more strongly on the majority of statements. Again, one cannot help but wonder if instructor opinion is swayed by the convenience and time-saving of not grading paper homework.

During the debriefing meeting with instructors, it was suggested that the requirement of turning in paper homework each day might have a positive effect on attendance, but this study does not support that. Some students may have improved attendance with paper homework, while others may actually have better attendance with online homework. These students may prefer the feeling of anonymity that online homework provides. If they don't have their homework done, then it is not immediately obvious to the instructor or the other students.

This study indicates that non-traditional students might have a slight preference for paper homework. This information should be available to advisors and to students. When students register for classes they should know if online or paper homework will be required. Taking this information into account may help students enroll in classes that are better suited to their learning styles. Different learning styles and preferences will influence attitude, which may in turn, influence achievement and persistence. As suggested by Kinney & Robertson (2003), students should have choices.

The conclusion of this study is that online homework in conjunction with graded paper quizzes and face-to-face instruction does not have a negative effect on achievement or persistence. This conclusion supports what other researchers have found (see Table 1). Instructors who choose this form of homework can continue to offer it knowing that students enjoy quick and detailed feedback, and have access to online support videos and explanations that may not be available with traditional paper homework. These conclusions should only be applied to similar situations: face-to-face classes that include written feedback in the form of quizzes as well as computerized feedback. Specifically, this research cannot be applied to entirely online courses.

Recommendations For Further Study

LaRose (2010) hypothesized that it was *not* the homework format (online or paper) that made a difference in achievement, but it was the fact that the homework contributed to the course grade. Homework can be graded for correctness, for completion, for demonstration of understanding, or not graded at all. Gutarts and Bains

(2010) hypothesized that feedback (even in the form of solutions sets) was the component that most affected achievement. Does receiving "credit" for homework improve achievement or does the actual feedback improve achievement? Future investigation should explore the effects of the written versus computerized feedback.

Most of the sections in this study (with the exception of beginning algebra) gave written feedback in the form of quizzes. Recall, beginning algebra was the only course level that had a statistically significant difference in achievement. These two facts may have been unrelated, but this certainly warrants further investigation.

The significance of the interaction between course level and homework type should be further explored. This study included four levels of developmental homework, but did not include college-level mathematics courses. Cooper, Jorgianne and Patall (2006) showed that homework has a more positive effect on grades 7-12 than it does on younger students. Is there a similar trend when comparing developmental level to college level mathematics?

Future studies should consider the independent variable of instructor. For reasons of statistical analysis (quasi-separation and multicollinearity) the independent variable instructor was removed from the models. Therefore, no conclusions can be made about the effect of instructor/ homework type interaction on achievement, persistence, and attitude. But it may be that a future study could focus more in the influence of the instructor. It might be that the instructor factor had a bigger influence on the outcomes than other factors.

Given the results of this study, future research should focus on the relationship between attitude and online homework and subpopulations. It appears that there may be some differences in how Alaska Native versus non-Native and non-traditional versus traditional students view and experience online homework. Trautwein, Schnyder, Niggli, Neumann and Ludtke (2009) recommended that homework/ achievement models include factors such as sociological issues, prior achievement and affective characteristics. While the models presented in this research did include a pre-test as a measure of prior achievement, it was not focused on prior achievement. This is an important issue when researching subpopulations such as Alaska Natives, who may not have the same access to high quality K-12 education.

Native students rated homework (of either type) lower than non-Native students. This could have an impact on the role and value that homework plays in the teaching and learning of Native students. Flores and Roberts (2008) found that de-emphasizing homework with low income, mostly Latino high school students was a productive strategy for raising student achievement. A similar study should be explored with Alaska Native students.

During the data analysis the main effects of the independent variables were described and summarized in Table 18. However, the research questions limited further analysis and discussion of the main effects not germane this study. For example, time of day had a statistically significant effect on four of the seven dependent variables. Native status had an effect on five dependent variables, while non-traditional status had an effect on two dependent variables. What is the relationship between these independent and dependent variables? What other factors should be considered? Future research should explore the relationship between these confounding factors.

The goal of developmental education is to help students succeed in their higher education goals. Developmental students are developing both academic and affective skills needed to engage in college level courses. Pedagogical decisions do have an effect on both academic and affective skills. Research like this helps higher education make decisions based on data and careful analysis, rather than on intuition, anecdotal observations, and gut feelings.

The improved quality of online homework programs, the increased availability of open-source textbooks, support from websites such as *Khan Academy,* and *You Tube,* and the significant cost of textbooks are reasons why online homework is likely to be used more and more in the future. Consistent with other studies, this study does not indicate that online homework is the panacea for improving achievement. When online homework is used in conjunction with other written feedback it is possible to expect similar results.

References

ACT. (2005). Crisis at the core: preparing all students for college and work. Retrieved from http://www.act.org/research/policymakers/pdf/crisis_report.pdf

ACT. (2011). Condition of college and career readiness 2011. Retrieved from http://www.act.org/research/policymakers/cccr11/pdf/ConditionofCollegeandCareerReadiness2011.pdf crisis_report.pdf

Agresti, A. (2002). *Categorical Data Analysis, 2nd ed.* (2002). Hoboken, NJ: John Wiley & Sons, Inc.

Alliance For Education (2008). American Indian and Alaska Native students and U.S.high schools. Retrieved from http://www.all4ed.org/files/AmerIndianAKNative_FactSheet.pdf

American Mathematical Association of Two-Year Colleges (AMATYC). (2006). Beyond crossroads: implementing mathematics standards in the first two years of college, Memphis: Author.

American Mathematical Association of Two Year Colleges (AMATYC). (2010). Mission Statement. Retrieved from http://www.amatyc.org/?page=MissionStatement

Armington, T. (Ed.). (2002). *Best Practices in Developmental Mathematics.* Mathematics Special Professional Interest Network National Association for Developmental Education.

Baily, T., Jeong, D.W., and Cho, S. (2009). Referral, enrollment and completion in developmental education sequences in community colleges. *Economics of Education Review, 29(2010),* 255-270.

Berg, S. L. (2005). Two sides of the same coin: reaching non-traditional students. *The Community College Enterprise, 11*(2), 7-20.

Biswas, R.R. (2007). Accelerating remedial mathematics education: how institutional innovation and state policy interact. Retrieved May 21, 2012 from http://www.jff.org/sites/default/files/RemedialMath_3.pdf

Boylan, H. (2011). Improving success in developmental mathematics: an interview with Paul Nolting. *Journal of Developmental Education, 34*(3), 20-27.

Boylan, H. (2009). Targeted intervention for developmental education students (T.I.D.E.S). *Journal of Developmental Education, 32*(3), 14-22.

Boylan, H. (2002). *What works: research-based best practices in developmental education.* Boone, NC: Continuous Quality Improvement Network with the National Center for Developmental Education.

Brewer, D., & Becker, K. (2010). Online homework effectiveness for underprepared and repeating college algebra students. *Journal of Computers in Mathematics and Science Teaching, 29*(4), 353-371.

Burch, K., & Kuo, Y. (2010). Traditional vs. online homework in college algebra. *Mathematics and Computer Education, 44*(1), 53-63.

Burnett, B., & Lampert, J. (2011). Teacher education and the targeting of disadvantage. *Creative Education, 2*(5), 446-451.

Butler, M., & Zerr, R. (2005). The use of online homework systems to enhance out-of-class student engagement. *The International Journal for Technology in Mathematics Education, 12*(2), 51-58.

Campbell, C. A., & Brigman, G. (2005). Closing the achievement gap: A structured approach to group counseling. *Journal for Specialist in Group Work, 30*(1), 67 -82.

Carifio, J. & Carey, T. (2009). A critical examination of current minimum grading policy recommendations. *The High School Journal, 93*(1), 23-37.

Carnegie Corporation (2009). *The opportunity equation: transforming mathematics and science education for citizenship and the global economy.* Retrieved http://carnegie.org/fileadmin/Media/Publications/PDF/OpportunityEquation.pdf

Carnine, D. (2000). The nature and roles of research in improving achievement in mathematics. Journal for Research in Mathematics Education, 31(2), 138. Retrieved from http://search.proquest.com/docview/223493800?accountid=14470

Carter, M. (2004). An analysis and comparison of the effects of computer-assisted Instruction versus traditional lecture instruction on student attitudes and achievement in a college remedial mathematics course. *UMI Dissertation Services.* (UMI No. 3128520)

Clery, S. (2011, May/June). *Gateway coursework: time to completion.* (Vol. 6, No. 3). Silver Spring, MD: Achieving the Dream.

Cobb, P., Yackel, E., & Wood, T. (1992). A constructivist alternative to the representational view of mind in mathematics education. *Journal for Research in Mathematics Education,* 2-33.

Cooper, H., Jorgianne, C. R., & Patall, E. A., (2006). Does homework improve academic achievement? A synthesis of research, 1987-2003. *Review of Educational Research*, 76(1), 1-9, 11-17, 19-21, 28-29, 37, 41, 43 45,47- 62.

Cox, K. B. (2011). Putting classroom grading on the table: A reform in progress. *American Secondary Education*, 40(1), 67-87.

Cox, T., & Singer, S. (2011). Taking the work out of homework. *Mathematics Teacher*, 104(7), 514-519.

Crawley, F.E, Fewell, M. D, & Sugar, W.A. (2009). Researcher and researched: the phenomenology of change from face-to-face to online instruction. *Quarterly Review of Distance Education, 10*(2), 165-176.

Davis, R. J., & Palmer, R. T. (2010). The role of postsecondary remediation for African American students: A review of research. *The Journal of Negro Education, 79*(4), 503-520.

DeVoe, J.F., and Darling-Churchill, K.E. (2008). Status and Trends in the Education of American Indians and Alaska Natives: 2008 (NCES 2008- 084). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Devore, J. (2000). *Probability and Statistics for Engineering and the Sciences.* Pacific Grove, CA: Brooks/Cole.

Dillman, D. (2000). *Mail and Internet Surveys, The Tailored Design Method.* NY, NY: John Wiley & Sons, Inc.

Ehrlich, T. (1998). Reinventing John Dewey's "Pedagogy as a university discipline". *The Elementary School Journal, 98*(5). 489-509.

Elikai, F., & Schuhmann, P. (2010). An examination of the impact of grading policies on students' achievement. *Issues in Accounting Education, 25*(4), 677-693.

Erickson, D., & Hirshberg, D. (2008). *Alaska Native Graduates of UAA: What Can They Tell Us?* UA Research Summary No. 11. Institute of Social and Economic Research: University of Alaska Anchorage.

Fennema, E., & Sherman, J.A. (1976). Fennema-Sherman mathematics attitude scales: instruments designed to measure attitudes toward learning of mathematics by females and males. *Journal for Research in Mathematics Education, Nov 76,* 324 326.

Fike, D.S., & Fike, R. (2007). Does faculty employment status impact developmental mathematics outcomes? *Journal of Developmental Education, 31*(1), 2-11.

Flores, A. (2007). Examining disparities in mathematics education: achievement gap or opportunity gap? *The High School Journal*, *91*(1), 29-42.

Flores, S., & Roberts, W. (2008). Productive strategies for raising student achievement in algebra: A personal view from two high school principals. *National Association of Secondary School Principals. NASSP Bulletin, 92*(4), 305-315.

George, M. (2010). Ethics and motivation in remedial mathematics education. *Community College Review, 38*(1), 82-92.

Guillory, R. M. (2009). American Indian/Alaska native college student retention strategies. *Journal of Developmental Education, 33*(2), 12 14,16,18,20-21,38.

Gutarts, B., & Bains, F. (2010). Does mandatory homework have a positive effect on student achievement for college students studying calculus? *Mathematics and Computer Education, 44*(3), 233-244.

Hagerty, G., & Smith, S. (2005). Using the web-based interactive software Aleks to enhance college algebra. *Mathematics and Computer Education, 39*(3), 183-194.

Halcrow, C., & Dunnigan, G. (2012). Online homework in calculus I: Friend or foe? *Primus : Problems, Resources, and Issues in Mathematics Undergraduate Studies, 22*(8), 664-682.

Hallett, R. E., & Venegas, K. M. (2011). Is increased access enough? advanced placement courses, quality, and success in low-income urban schools. *Journal for the Education of the Gifted. 34*(3), 468-487, 544, 546.

Hong, E., Peng, Y., & Rowell L.L. (2009). Homework self-regulation: grade, gender, and achievement-level differences. *Learning and Individual Differences,* 19, 269 -276.

Hong, E., Wan, M, & Peng, Y., (2011). Discrepancies between students' and teachers' perceptions of homework. *Journal of Advanced Academics, 22*(2), 280-308.

Jacobson, E. (2006). Computer homework effectiveness in developmental education. *Journal of Developmental Education, 29*(3), 2-4, 6, 8.

Johnson, A. (2008). *A short guide to action research, 3rd ed*. Boston, MA: Pearson Education, Inc.

Kendricks, K.D. (2011). Creating a supportive environment to enhance computer based learning for underrepresented minorities in college algebra classrooms. *Journal of the Scholarship and Teaching and Learning, 12*(4), 12-25.

Kendricks, K., & Arment, A. (2011). Adopting a K-12 family model with undergraduate research to enhance STEM persistence and achievement in underrepresented minority students. *Journal of College Science Teaching, 41*(2), 22-27.

Kinney, D. P., & Robertson, D. F. (2003). Technology makes possible new models for delivering developmental mathematics instruction. *Mathematics and Computer Education, 37*(3), 315-328.

Kodippili, A., & Senaratne, D. (2008). Is computer-generated interactive mathematics homework more effective than traditional instructor-graded homework? *British Journal of Educational Technology, 39*(5), 928-932.

Kutner, M., Nachtsheim, C., Neter, J., & Li, W. (2005). *Applied Linear Statistical Models, 5th ed.* NY, NY: McGraw-Hill/Irwin.

LaRose, P. G. (2010). The impact of implementing web homework in second-semester calculus. *Primus : Problems, Resources, and Issues in Mathematics Undergraduate Studies, 20*(8), 664-683.

Lenz, L. (2010). The effect of web-based homework system on student outcomes in a first-year mathematics course. *Journal of Computers in Mathematics and Science Teaching, 29*(3), 233-246.

Li, Q., & Edmonds, K. A. (2005). Mathematics and at-risk adult learners: Would technology help? *Journal of Research on Technology in Education*, *38*(2), 143 -166.

Lumina Foundation. (2013). A stronger nation through higher education. Retrieved from http://www.luminafoundation.org/publications/A_stronger_nation_through_higher_education-2013.pdf

Lumina Foundation. (2012). A stronger nation through higher education. Retrieved from http://www.luminafoundation.org/publications/A_Stronger_Nation-2012.pdf

Merriam, S. B. (2001). Andragogy and self-directed learning: Pillars of adult learning theory. *New directions for adult and continuing education, 2001*(89), 3-14.

Michael, A., Dickson, J., Ryan, B., & Koefer, A. (2010). College prep blueprint for bridging and scaffolding incoming freshman: practices that work. *College Student Journal, 44*(4), 969-978.

Mulvey, M. (2009). Characteristics of under-prepared students: who are "the under prepared"?. *Research & Teaching in Developmental Education, 2009*(25), 29-58.

NADE, National Association Developmental Education. (2012). Retrieved July 13, 2013 from http://www.nade.net/aboutdeved.html.

National Center for Developmental Education. (2013). Retrieved August 9, 2012 from http://ncde.appstate.edu/

NCES, U.S. Department of Education, National Center for Education Statistics. (2012a). *The condition of Education 2011* (NCES 2012-045), Indicator 45.

NCES, U.S. Department of Education, National Center for Education Statistics. (2012b). Retrieved from http://nces.ed.gov/pubs/web/97578e.asp

NCTM, National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

NCTM, National Council of Teachers of Mathematics. (2012). Closing the opportunity gap in mathematics education. Retrieved from http://www.nctm.org/uploadedFiles/About_NCTM/Position_Statements/O pportunity%20Gap.pdf

Oates, G. L. St. C. (2009). An empirical test of five prominent explanations for the black -white academic performance gap. *Social Psychology of Education: An International Journal, 12*(4), 415-441.

Pierce, R., & Stacey, K. (2001). Observations on students' responses to learning in a CAS environment. *Mathematics Education Research Journal*, *13*(1), 28-46.

Pitre, C. C., & Pitre, P. (2009). Increasing underrepresented high school students college transitions and achievements: TRIO educational opportunity programs. *National Association of Secondary School Principals. NASSP Bulletin, 93*(2), 96-110.

Potocka, K. (2010). An entirely online developmental mathematics course: creation and outcomes. *Primus: Problems, Resources, and Issues in Mathematics Undergraduate Studies*, *20*(6), 498-516.

Provasnik, S., and Planty, M. (2008). *Community colleges: special supplement to the condition of education 2008* (NCES 2008-033). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Ramdass, D., & Zimmerman, B. J. (2011). Developing self-regulation skills: the important role of homework. *Journal of Advanced Academics, 22*(2), 194- 218.

Roehl, R. (2010). Correlation between teacher turnover rates in the state of Alaska and standardized test scores in the area of mathematics on the standards based assessments/ high school qualifiying exam. *ProQuest Dissertations and Theses.* (UMI No. 3421516)

Sjøberg, S. (2007). Constructivism and learning. In Baker, E.; McGaw, B. & Peterson P (Eds), *International Encyclopaedia of Education* (3rd ed.) Oxford: Elsevier.

Smolira, J. (2008). Student perceptions of online homework in introductory finance courses. *Journal of Education for Business,* 90-94.

Sorden, S.D. (2013). Cognitive Theory of Multimedia Learning. In B. J. Irby, G. Brown & R. Lara-Alecio (Eds.), *Handbook of Educational Theories*. Charlotte: Information Age Publishing Inc.

Stillson, H., & Nag, P. (2009). Aleks and Math XL: using online interactive systems to enhance remedial algebra course. *Mathematics and Computer Education, 43*(3), 239-247.

Sullivan, M. M. (2005). Teaching mathematics to college students with mathematics related learning disabilities: report from the classroom. *Learning Disability Quarterly*, *28*(3), 205-220.

Taylor, J.M. (2008). The effects of a computerized-algebra program on mathematics achievement of college and university freshman enrolled in a developmental mathematics course. *Journal of College Reading and Learning*, *39*(1), 35-53.

Trautwein, U., Schnyder, I., Niggli, A., Neumann, M., & Ludtke, O. (2009). Chameleon effects in homework research: The homework-achievement association depends on the measures used and the level of analysis chosen. *Contemporary Educational Psychology, 34*, 77-88.

University of Alaska Fairbanks (2014). *University facts.* Retrieved January 19, 2014 from http://www.uaf.edu/facts/

U.S. Census Bureau. (2014, January 19). *State & county Quickfacts: Fairbanks North Star Borough, Alaska.* Retrieved January 19, 2014, from http://quickfacts.census.gov/qfd/states/02/02090.html

Weems, G. (1998). The impact of homework collection on performance in intermediate algebra. *Research and Teaching in Developmental Education, 15*(1), 21-26.

Weiss, C. C., Carolan, B. V., & Baker-Smith, E. (2010). Big school, small school: (re)testing assumptions about high school size, school engagement and mathematics achievement. *Journal of Youth and Adolescence, 39*(2), 163-176.

White, J. L., Altschuld, J. W., & Lee, Y. (2006). Cultural dimensions in science, technology, engineering and mathematics: Implications for minority retention research. *Journal of Educational Research & Policy Studies*, 6(2), 41-59.

Wolfle, J. D. (2012). Success and persistence of developmental mathematics students based on age and ethnicity. *The Community College Enterprise,* 18(2), 39-54.

Zerr, R., (2007). A quantitative and qualitative analysis of the effectiveness of online homework in first-semester calculus. *Journal of Computers and Science Teaching*, *26*(1), 55-73.

Appendix A
Institutional Review Board Approval

UAF
UNIVERSITY OF ALASKA
FAIRBANKS

(907) 474-7800
(907) 474-5444 fax
fyirb@uaf.edu
www.uaf.edu/irb

Institutional Review Board

909 N Koyukuk Dr. Suite 212, P.O. Box 757270, Fairbanks, Alaska 99775-7270

May 10, 2012

To:	Ute Kaden, Ed. D. Principal Investigator
From:	University of Alaska Fairbanks IRB
Re:	[329093-1] Analysis and Comparison of the Effects of Online Homework on Achievement, Persistence and Attitude in Developmental College Mathematics Students

Thank you for submitting the New Project referenced below. The submission was handled by Expedited Review under the requirements of 45 CFR 46.110, which identifies the categories of research eligible for expedited review.

Title:	Analysis and Comparison of the Effects of Online Homework on Achievement, Persistence and Attitude in Developmental College Mathematics Students
Received:	April 29, 2012
Expedited Category:	*7*
Action:	APPROVED
Effective Date:	May 10, 2012
Expiration Date:	May 10, 2013

This action is included on the May 10, 2012 IRB Agenda.

No changes may be made to this project without the prior review and approval of the IRB. This includes, but is not limited to, changes in research scope, research tools, consent documents, personnel, or record storage location.

UNIVERSITY OF ALASKA FAIRBANKS

(907) 474-7800
(907) 474-5444 fax
fyirb@uaf.edu
www.uaf.edu/irb

Institutional Review Board

909 N Koyukuk Dr. Suite 212, P.O. Box 757270, Fairbanks, Alaska 99775-7270

April 19, 2013

To:	Ute Kaden, Ed. D. Principal Investigator
From:	University of Alaska Fairbanks IRB
Re:	[329093-3] Analysis and Comparison of the Effects of Online Homework on Achievement, Persistence and Attitude in Developmental College Mathematics Students

Thank you for submitting the Amendment/Modification Protocol referenced below. The submission was handled by Expedited Review under the requirements of 45 CFR 46.110, which identifies the categories of research eligible for expedited review.

Title:	Analysis and Comparison of the Effects of Online Homework on Achievement, Persistence and Attitude in Developmental College Mathematics Students
Received:	April 3, 2013
Expedited Category:	*7*
Action:	APPROVED
Effective Date:	April 16, 2013
Expiration Date:	May 10, 2014

This action is included on the May 1, 2013 IRB Agenda.

No changes may be made to this project without the prior review and approval of the IRB. This includes, but is not limited to, changes in research scope, research tools, consent documents, personnel, or record storage location.

Appendix B
Informed Consent Student Form

Informed Consent Form
Analysis and Comparison of the Effects of Online Homework on Achievement, Persistence, and Attitude in Developmental College Mathematics Students

IRB #: 329093-1
Date Approved: May 10, 2012

Description of the Study:
You are being asked to take part in a research study about the use of online homework. We will look at the effect online homework has on the math you will learn. We will look at the number of students who pass the class. We will look at the effect online homework has on attendance, and on the number of students who withdrawal. We will look at the effect online homework has on attitude towards math.

The goal of this study is to learn if the use of online homework is a beneficial. You are being asked to take part in this study because you are enrolled in a developmental college math course. Please read this form and ask any questions before you agree to be in the study.

If you decide to take part, you will be asked to complete a questionnaire about yourself. The questionnaire will help determine if you are a non-traditional or Alaskan Native student. You will be asked to complete a math pre-test, and a survey asking you some questions about your attitude toward mathematics. At the end of the semester, you will be asked to take a math post-test (this will be the normal final exam). You will be asked to complete the attitude survey again.

Risks and Benefits of Being in the Study: There are no anticipated risks for involvement in this study. There will be no direct benefit to you.

Confidentiality: Any information about you will be kept strictly confidential. This includes answers to questionnaires, history, personal characteristics or ethnicity.

- Any information with your name attached will not be shared with anyone outside the research team.
- We will protect your confidentiality by coding your information with a number. This way no one can trace your answers to your name. At the end of the study we will dispose of all electronic and paper documents.
- We will limit access to identifiable information. The research staff knows the importance of confidentiality. All research records will be stored locked cabinets. Electronic documents will be stored on computers that are locked by passwords.

- The data from this study may be used in reports, presentations, and publications. But you will not be individually identified.

Voluntary Nature of the Study: Your decision to take part in the study is voluntary. You are free to choose whether or not to take part in the study. If you decide to take part in the study you can stop at any time or change your mind and ask to be removed from the study. Whether or not you choose to participate will not affect your grade on anything you do in this class. It will not affect your homework grade, your exam grades, your final exam grade or your final grade in this class.

Contacts and Questions: If you have questions now, feel free to ask me (us) now. If you have questions later, you may contact Amy Barnsley, 907 474 7372.

If you have questions or concerns about your rights as a research participant, you can contact the UAF Office of Research Integrity at 474-7800 (Fairbanks area) or 1-866-876-7800 (toll-free outside the Fairbanks area) or fyirb@uaf.edu.

Statement of Consent: I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been provided a copy of this form.

____
Signature of Participant & Date

____
Signature of Person Obtaining Consent & Date

Appendix C
Informed Consent Instructor Form

Informed Consent Form
Analysis and Comparison of the Effects of Online Homework on Achievement, Persistence, and Attitude in Developmental College Mathematics Students

IRB #: 329093-1
Date Approved: May 10, 2012

Description of the Study:
You are being asked to take part in a research study about effects of online homework on achievement, persistence, and attitude. The goal of this study is to learn if the use of online homework improves mathematical achievement, pass rates, withdrawl rates, and attitudes of developmental college students. You are being asked to take part in this study because you are teaching a developmental college mathematics course. Please read this form and ask any questions you may have before you agree to be in the study.

If you decide to take part, you will asked to administer a pre-test and post-test (normal final exam), to administer a confidential survey and questionnaire and keep attendance. You will be asked to grade paper and pencil homework in some sections and use online homework in other sections. You will not have to grade the pre-test. You will have to grade the post-test (normal final exam).

Risks and Benefits of Being in the Study: There are no anticipated risks for involvement in this study. I am not in a supervisory position at the university where you work, and I am not a supervisor to you in any manner. Participation or non-participation in this study will not reflect on your work performance evaluation in any manner. There will be no direct benefit to you.

Confidentiality:

- Any information obtained about you from the research including answers to questionnaires, history, personal characteristics or ethnicity, will be kept strictly confidential.
- Any information with your name attached will not be shared with anyone outside the research team.
- We will protect your confidentiality by coding your information with a number so no one can trace your answers to your name, properly disposing of computer sheets and other papers, limiting access to identifiable information, telling the research staff the importance of confidentiality, and storing research records in locked cabinets.
- The data derived from this study may be used in reports, presentations, and publications but you will not be individually identified.

Voluntary Nature of the Study:
Your decision to take part in the study is voluntary. You are free to choose whether or not to take part in the study. If you decide to take part in the study you can stop at any time or change your mind and ask to be removed from the study. Whether or not you choose to participate, will not affect your job performance evaluation.

Contacts and Questions:
If you have questions now, feel free to ask me (us) now. If you have questions later, you may contact Amy Barnsley, 907 474 7372.

If you have questions or concerns about your rights as a research participant, you can contact the UAF Office of Research Integrity at 474-7800 (Fairbanks area) or 1-866-876-7800 (toll-free outside the Fairbanks area) or fyirb@uaf.edu.

Statement of Consent:
I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been provided a copy of this form.

____
Signature of Participant & Date

____
Signature of Person Obtaining Consent & Date

Appendix D
Fennema-Sherman Attitude Scale

Modified Fennema- Sherman Attitude Scales
By Diana Doepken, Ellen Lawsky and Linda Padwa

Directions: On the following 123is a series of sentences. You are to mark your answer sheets by telling how you feel about them. Suppose a statement says:

I like mathematics.

If you strongly agree, circle A.

If you agree, but not so strongly, or if you only “sort of” agree, circle B.

If you are not sure about an answer or can’t answer it, circle C.

If you disagree, but tot so strongly, circle D.

If you disagree very much, circle E.

Do not spend much time with any statement, *but be sure to answer every statement*. There are no “right” or “wrong” answers. The only correct answers are those that are true *for you*. Work fast but carefully.

Do not write your name on this answer sheet. Your answer sheet will be labeled with a confidential identifier. Your answers will be kept confidential and all answer sheets will be destroyed at the conclusion of this study. Using this scale will help the researcher determine how the students feel about mathematics, in general.

1.	I am sure that I can learn math.	A	B	C	D	E
2.	Knowing mathematics will help me earn a living.	A	B	C	D	E
3.	I don't think I could do advanced math.	A	B	C	D	E
4.	Math will not be important to me in my life's work.	A	B	C	D	E
5.	Math is hard for me.	A	B	C	D	E
6.	I'll need mathematics for my future work.	A	B	C	D	E
7.	I am sure of myself when I do math.	A	B	C	D	E
8.	I don't expect to use much math when I get out of school.	A	B	C	D	E
9.	Math is a worthwhile, necessary subject.	A	B	C	D	E
10.	I'm not the type to do well in math.	A	B	C	D	E
11.	Taking math is a waste of time.	A	B	C	D	E
12.	Math has been my worst subject.	A	B	C	D	E
13.	I think I could handle more difficult math.	A	B	C	D	E
14.	I will use mathematics in many ways as an adult.	A	B	C	D	E
15.	I see mathematics as something I won't use very often when I get out of high school.	A	B	C	D	E
16.	Most subjects I can handle OK, but I just can't do a good job with math.	A	B	C	D	E
17.	I can get good grades in math.	A	B	C	D	E
18.	I'll need a good understanding of math for my future work.	A	B	C	D	E
19.	I know I can do well in math.	A	B	C	D	E
20.	Doing well in math is not important for my future.	A	B	C	D	E
21.	I am sure I could do advanced work in math.	A	B	C	D	E
22.	Math is not important for my life.	A	B	C	D	E
23.	I'm no good in math.	A	B	C	D	E
24.	I study math because I know how useful it is.	A	B	C	D	E

Key to Fennema-Sherman Attitude Scale

Key to Modified Fennema-Sherman Scale for Math and Science

Key:

C = Personal confidence about the subject matter
U = Usefulness of the subject's content

+ = Question reflects positive attitude
- = Question reflects negative attitude

Question #	Category of Question	Attitude
1	C	+
2	U	+
3	C	-
4	U	-
5	C	-
6	U	+
7	C	+
8	U	-
9	U	+
10	C	-
11	U	-
12	C	-
13	C	+
14	U	+
15	U	-
16	C	-
17	C	+
18	U	+
19	C	+
20	U	-
21	C	+
22	U	-
23	C	-
24	U	+

Scoring Directions:

Each positive item receives the score based on points

A = 5 B = 4 C = 3 D = 2 E = 1

The scoring for each negative item should be reversed

A = 1 B = 2 C = 3 D = 4 E = 5

Add the scores for each group, C and U to get a total for that attitude.

The highest possible score for each group of statements is 60 points.

Appendix E
Student Characteristic Survey

Directions:

Read the following statements. If the statement describes you, circle Yes. If it does not describe you circle No. Do the best you can to answer every question. However, if you do not know leave it blank.

Do not write your name on this answer sheet. Your answer sheet will be labeled with a confidential identifier. Your answers will be kept confidential and all answer sheets will be destroyed at the conclusion of this study.

Yes / No Did you delay enrollment in college after high school? That is, did you enter postsecondary education AFTER the calendar year that you finished high school?

Yes / No Do you attend college part time for at least part of the academic year?

Yes / No Do you work full time (35 hours or more per week) while enrolled in college?

Yes / No Are you considered financially independent for purposes of determining eligibility for financial aid?

Yes / No Do you have dependents other than a spouse or partner? (usually children, but sometimes others)?

Yes / No Are you a single parent, either not married or married but separated and has dependents?

Yes / No Do you have a high school diploma? This includes completing high school with a GED or other high school completion certificate.

Yes / No Are you Alaska Native?

Appendix F
Pre-algebra Pre-Test

Pre Algebra Pre Test

ID Sticker:

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Add.

1) 1) ______

$$\begin{array}{r} 8119 \\ \underline{+\ 9194} \end{array}$$

A) 224 B) 17,313 C) 123 D) 203

Subtract.

2) 2) ______

$$\begin{array}{r} 749 \\ \underline{-\ 475} \end{array}$$

A) 274 B) 174 C) 1224 D) 264

Determine the place value of the digit 3 in the whole number.

3) 25,304,168 3) ______

A) thousands B) ten-thousands
C) hundreds D) hundred-thousands

Round the whole number to the given place.

4) 997 to the nearest ten 4) ______

A) 980 B) 1010 C) 990 D) 1000

Find the quotient.

5) $\frac{8}{0}$ 5) ______

A) 1 B) 0 C) 8 D) undefined

Find the average of the list of numbers.

6) 66, 70, 67, 71, 98, 65, 67 6) ______

A) 67 B) 82 C) 72 D) 71

Evaluate the expression for the given replacement values.

7) $y + x$ for $x = 6.1$, $y = 8$ 7) ______

A) 6.9 B) 1.9 C) 14.1 D) 14.2

Decide whether the given number is a solution of the given equation.

8) Is 8 a solution of $p + 7 = 15$? 8) ______

A) yes B) no

Simplify.

9) $|-6| - |6|$ 9) ______

A) 6 B) -12 C) 12 D) 0

Simplify the expression by combining like terms.

10) $2y - y - 9y$ 10) ______

A) $-8y$ B) $-6y$ C) $-7y - y$ D) $-7y$

Solve the equation.

11) $x + 9 = 15$ 11) ______

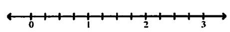
A) 6 B) 24 C) -6 D) -24

12) $51 = 6x + 3$ 12) ______

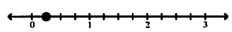
A) 8 B) 5 C) 42 D) 46

Graph the fraction on a number line.

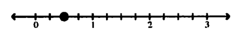
13) $\frac{1}{4}$ 13) ______



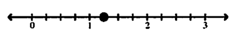
A)



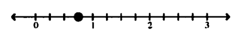
B)



C)



D)



Add or subtract as indicated. Write the answer in simplest form.

14) $\frac{1}{4} + \frac{1}{9}$ 14) ______

A) $\frac{2}{13}$ B) $\frac{13}{36}$ C) $\frac{2}{9}$ D) $\frac{7}{18}$

Insert <, >, or = between the pair of numbers to form a true statement.

15) 0.188 _____ 0.185 15) ______

A) = B) < C) >

Find the median. If necessary, round to one decimal place.

16) 4, 7, 12, 27, 40, 41, 46 16) ______

A) 12 B) 27 C) 40 D) 25.8

Solve.

17) The ratio of the weight of an object on Earth to the weight of the same object on Pluto is 100 to 3. If a buffalo weighs 3972 pounds on Earth, find the buffalo's weight on Pluto. (Round to the nearest pound.) 17) ______

A) 8 lb B) 11,916 lb C) 119 lb D) 1,191,600 lb

Translate to a proportion and solve. Round to the nearest hundredth, if necessary.

18) 19 is 5% of what number? 18) ______

A) 95 B) 38 C) 380 D) 3800

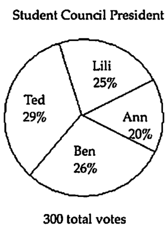
Find the square root.

19) $\sqrt{16}$ 19) ______

A) $\frac{1}{16}$ B) 16 C) 4 D) 256

The circle graph shows the results of the student council presidential election and the percent of the vote each person received.

20) 20) ______



Who got the most votes?

A) Ben B) Lili C) Ted D) Ann

Appendix G
Beginning Algebra Pre-Test

Beginning Algebra Pre Test

ID Sticker:

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Solve the equation.

1) $10x + 6 = -84$ 1) ______

A) -100 B) -96 C) -9 D) 14

Multiply.

2) $4(x + 2)$ 2) ______

A) $x + 8$ B) $4x + 6$ C) $4x + 2$ D) $4x + 8$

Simplify.

3) $\frac{8}{3} + \frac{1}{8} \cdot \frac{1}{4}$ 3) ______

A) $\frac{1}{12}$ B) $\frac{4}{3}$ C) $\frac{16}{3}$ D) $\frac{256}{3}$

Solve.

4) $\frac{8}{21}x = -\frac{8}{45}$ 4) ______

A) $-\frac{21}{5}$ B) $-\frac{35}{12}$ C) $-\frac{12}{35}$ D) $-\frac{7}{15}$

Find the value of the expression. Give the result as a decimal.

5) $\frac{62}{7} - 4(62)$ 5) ______

A) -23.943 B) -19.486 C) -23.633 D) -18.1

Solve the equation.

6) $-34.4 = -8.6x$ 6) ______

A) -25.8 B) 25.8 C) 4.0 D) 2.0

Translate to an equation and solve.

7) 60% of what number is 69? 7) ______

A) 11.5 B) 41.4 C) 1150 D) 115

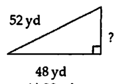
Find the square root.

8) $\sqrt{\frac{4}{81}}$ 8) ______

A) $\frac{\sqrt{4}}{9}$ B) $\frac{2}{\sqrt{81}}$ C) $\frac{9}{2}$ D) $\frac{2}{9}$

Find the unknown length in the right triangle. If necessary, approximate the length to the nearest thousandth.

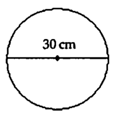
9) 9) ______



A) 20 yd B) 25.144 yd C) 17.856 yd D) 4 yd

Find the exact or approximate circumference of the circle, as indicated.

10) Find the exact circumference. 10) ______



A) 30π cm B) 60π cm C) 15π cm D) 900π cm

Solve the equation.

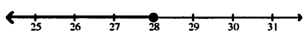
11) $\frac{2x}{5} - \frac{x}{3} = 4$ 11) ______

A) -120 B) -60 C) 120 D) 60

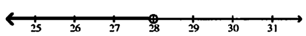
Solve the inequality.

12) $\frac{y}{4} \geq 7$ 12) ______

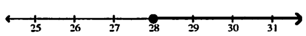
A) $\{y \mid y \leq 28\}$



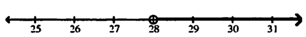
B) $\{y \mid y < 28\}$



C) $\{y \mid y \geq 28\}$

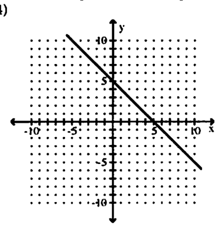


D) $\{y \mid y > 28\}$



State whether the slope of the line is positive, negative, 0, or is undefined.

14) 14) ______



A) 0 B) negative C) undefined D) positive

Use the power rule and the power of a product or quotient rule to simplify the expression.

15) $(-7x^4y^5z)^2$ 15) ______

A) $-7x^6y^7z$ B) $-49x^8y^{10}z^2$ C) $49x^8y^{10}z^2$ D) $14x^8y^{10}z^2$

Perform the division.

16) $\frac{9r^6 - 15r^5}{3r}$ 16) ______

A) $3r^5 - 5r^4$ B) $3r^6 - 5r^5$ C) $3r^7 - 5r^6$ D) $9r^5 - 15r^4$

Factor the trinomial completely. If the polynomial cannot be factored, write "prime."

17) $x^2 + x - 72$ 17) ______

A) $(x - 8)(x + 9)$ B) $(x + 1)(x - 72)$ C) $(x - 9)(x + 8)$ D) prime

Solve the equation.

18) $x(6x + 18) = 0$ 18) ______

A) 0, 3 B) $0, -\frac{1}{3}$ C) 0, -3 D) $0, \frac{1}{3}$

Find the LCD for the list of rational expressions.

19) $\frac{7}{t}, \frac{2}{t-6}$ 19) ______

A) t B) t - 6 C) 14 D) t(t - 6)

Solve the equation.

20) $\frac{62}{x} = 7 - \frac{1}{x}$ 20) ______

A) 8 B) $\frac{62}{7}$ C) 9 D) $\frac{7}{61}$

Appendix H
Intermediate and Intensive Intermediate Algebra Pre-Test

Intermediate Algebra Pre Test

ID Sticker:

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Factor the trinomial completely. If the polynomial cannot be factored, write "prime."

1) $x^2 - 4x - 21$ 1) ______

A) $(x - 7)(x + 3)$ B) $(x - 21)(x + 1)$ C) $(x + 7)(x - 3)$ D) prime

Perform the division.

2) $\dfrac{-9x^5 + 6x^4 - 24x^3}{-3x^4}$ 2) ______

A) $3x - 2$ B) $3x - 2 + \dfrac{8}{x}$ C) $3x + 6x^4 + \dfrac{8}{x}$ D) $11x - 2$

Solve the equation.

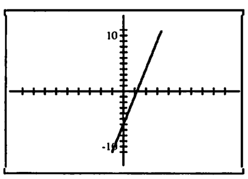
3) $3(5x + 2) - 31 = 12x - 1$ 3) ______

A) 72 B) 24 C) 8 D) -8

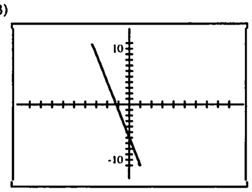
Match the equation with its graph.

4) $y = 5x + 6$ 4) ______

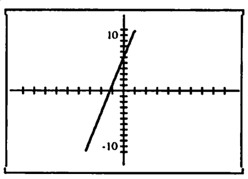
A)



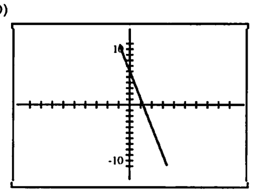
B)



C)



D)



Solve using the elimination method.

5) $-x - 7y = -29$
$7x + 7y = 35$ 5) ______

A) (1, 4) B) No solution C) (-4, 1) D) (2, 3)

Solve.

6) $-2x - (6x + 9) > 4 - (4x + 1)$ — 6) ______

A) $(-\infty, -3)$ B) $\left(-\infty, -\frac{1}{2}\right)$ C) $(-3, \infty)$ D) $(-\infty, 1)$

Solve. Give exact solutions.

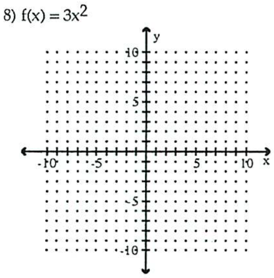
7) $(p + 6)^2 = 17$ — 7) ______

A) $\sqrt{17} - 6, -\sqrt{17} - 6$ B) $\sqrt{17} - \sqrt{6}$

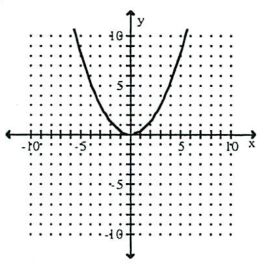
C) $\sqrt{17} + 6, -\sqrt{17} + 6$ D) $\sqrt{17} - 6$

Graph.

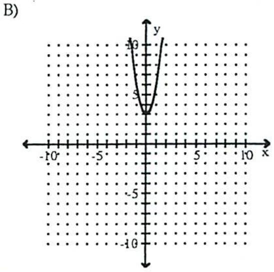
8) $f(x) = 3x^2$ — 8) ______



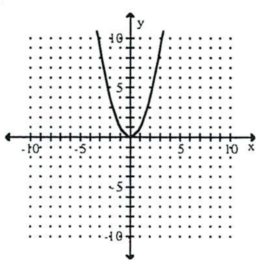
A)



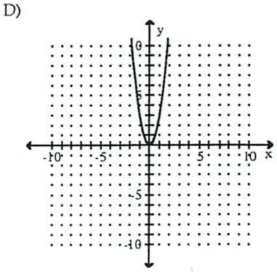
B)



C)

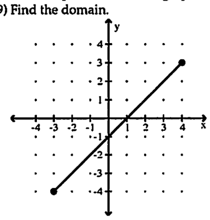


D)



For the function represented in the graph, determine the domain or range, as requested.

9) Find the domain. 9) ______



A) [2, -2] B) [-5, 5] C) [-3, 4] D) [-4, 5]

Convert to a logarithmic equation.

10) $5^2 = 25$ 10) ______

A) $2 = \log_{25} 5$ B) $2 = \log_5 25$ C) $5 = \log_2 25$ D) $25 = \log_5 2$

Appendix I

Homework Questionnaire for Students

	Directions: Indicate how strongly you agree or disagree with the following statements:					
	Additional questions:	strongly agree	agree	not sure	disagree	strongly disagree
1.	The homework for this class helped me learn the material.	A	B	C	D	E
2.	The homework for this class helped my final grade in this course.	A	B	C	D	E
3.	I did my homework for this class most of the time.	A	B	C	D	E
4.	I believe doing math homework is valuable.	A	B	C	D	E
5.	I am satisfied with the homework format for this class (online for some students, or paper and pencil for other students).	A	B	C	D	E

Appendix J
Homework Questionnaire for Instructors

Directions: Indicate how strongly you agree or disagree with the following statements:						
		strongly agree	agree	not sure	disagree	strongly disagree
1.	Online homework helped students learn the material.	A	B	C	D	E
2.	Paper and pencil homework helped students learn the material.	A	B	C	D	E
3.	I believe a mixture of paper and pencil and online homework would be most beneficial to students.	A	B	C	D	E
4.	Online homework helped student's final grade.	A	B	C	D	E
5.	Paper and pencil homework helped student's final grade.	A	B	C	D	E
6.	Students did the online homework most of the time.	A	B	C	D	E
7.	Students did paper and pencil homework most of the time.	A	B	C	D	E
8.	I believe doing homework is valuable.	A	B	C	D	E
9.	I am satisfied with the online homework format.	A	B	C	D	E
10.	I am satisfied with the paper and pencil homework format.	A	B	C	D	E
Please share any comments or feedback you have on the use of online verses paper and pencil homework.						

Appendix K
Sample Syllabus

Syllabus
Intermediate Algebra

Course: DEVM F105, 3 Credits
Time & Location:
R03 CRN 75001 MWF 2:15-3:15 Grue 305
R07 CRN 75005 T/Th 2:00-3:30 Duck 252
Term: Fall 2012
Assistant Professor: Amy E. Barnsley
E-Mail: amy.barnsley@alaska.edu
Office Phone: 474-7372
Mailbox: Located in 508C Gruening
Office Hours & Location: Gruening 508B, M/W/F 11:45- 12:45, Tues 1:00-2:00 other times by appointment
Textbook: Intermediate Algebra, 3rd Ed., Custom Edition with Aleks, Author: Mark Dugopolski, Publisher: McGraw Hill
Aleks Course Codes:
Tues/Thur (R07): **WDGNJ-RTXFW**
Mon/Wed/ Fri: (R03):**PQUT3-XTJHR**

Blackboard: Course materials (syllabus, calendar, your grades etc) will be available on Blackboard. You must be able to receive emails sent via Blackboard.

www.aleks.com: You will use an online homework program called Aleks. You must have daily access to the internet. Computers are available in the Math Lab in Gruening 406 and in Bunnell Building.

Course Description: Operations with rational expressions, radicals, rational exponents, logarithms, inequalities, quadratic equations, linear systems, functions, Cartesian coordinate system and graphing.

Course Goals: This course aims to help students build a secure foundation in algebra skills through meaningful contextual problems and situations, and to develop skills that will help students succeed in a college level math class.

Student Learning Outcomes for Intermediate Algebra

1. Solve linear absolute value equations
2. Solve linear inequalities
3. Solve systems of linear equations
4. Solve quadratic equations
5. Solve quadratic inequalities
6. Solve exponential equations
7. Solve logarithmic equations
8. Solve radical equations
9. Simplify and perform operations on radical expressions and rational exponents
10. Simplify and perform operations on complex numbers
11. Combine, compose and evaluate functions
12. Graph and interpret linear functions
13. Graph and interpret quadratic functions
14. Graph and interpret absolute value functions
15. Graph and interpret square root functions
16. Determine and graph inverse functions
17. Graph and interpret logarithmic functions
18. Graph and interpret exponential functions

19. Solve applied problems

Instructional Methods: The format of the class will involve lecture, strategies for problem solving, small group work and practice on daily homework and demonstration of learning homework, quizzes and exams. Online homework is required for this class.

Prerequisites: The prerequisite for this course is a grade of A, B, or C in DEVM 060, or placement into DEVM 105 by taking the Accuplacer in Testing Center, 2th floor Gruening. Students who do not meet the prerequisites by Friday, September 7 will be dropped from the course.

Grades: Grades are based on the following scale

90-100%	A
80-89%	B
70-79%	C
60-69%	D
0-59%	F

This represents a guarantee. The instructor reserves the right to improve grades beyond what is shown here. This is where attendance counts. If you come to almost every class, I will round up. For example, a grade of 78% will earn a B if you come to almost every class.

Your grade has five components:

ALEKS pie	15%
Aleks Homework	15%
Quizzes	10%
Exams (4)	40%
Final	20%

There will be four exams and a final. The tentative exam schedule is on the course calendar.

Final Exam:
pm, Location TBA

You are graded not only on correctness, but also on clarity of work. If I can't read your writing, then a correct answer **will not** get you full credit. You must show all steps. Just giving the answer will not earn full credit. Again, you must show all work.

Homework is due at 11:59 pm. The Aleks program will not allow you to work beyond 11:59 pm. NO LATE WORK WILL BE ACCEPTED. With the exception of university related trips, these include travel for sports competition, the university orchestra and field trips for classes, in which case you must make arrangements prior to your travel. Travel for work and sports practice will not excuse late work. I'll emphasize: **turn in work early if you will need to miss class**. A**ll assignments are available online and can be done early.**

As a policy, exams cannot be retaken. An exam is considered to be taken if you have started it. Exams cannot be missed except in extreme cases. If an excuse for an exam can be scheduled ahead of time, it must be scheduled in advance. Exams can be missed for some religious reasons. Medical require a note from a physician. Road conditions or transportation problems will not constitute an exception to this emergencies rule. The instructor reserves the right to offer retesting opportunities.

Keep all graded work until you get your final grade. If you believe a quiz, homework or exam was graded incorrectly please bring your concern forward immediately; but absolutely before the final exam.

There can be "technical" glitches which cause you to be unable to login to your homework. Do not leave your homework until the last minute. It is your responsibility to do on-line homework by the time it is due. Unless technical glitches are incurred by all members of the class they will not excuse a homework.

Math Lab & Tutors: Extra help is available for free. A tutor is available to help with questions at the scheduled times in Room 120 TVCC and Room 406 Gruening on the main Campus. Times are posted in these rooms. Study groups with classmates are encouraged. Videotapes/DVDs which accompany the text may be checked out in the Math Lab. The videos and textbook are on reserve in the library and can be checked out for 2 hours at a time.

Audits: A student who audits this course must attend class regularly. An auditing student does not need to take the exams but must turn in all homework and quizzes. A student cannot change this course to an audit if a homework or a quiz is missing.

Withdrawls: Last day for student-initiated and faculty-initiated drops (course does not appear on academic record): Friday, September 14. Last day for student-initiated and faculty-initiated withdrawls (W grade appears on academic record): Friday, October 26. I will do a faculty-initiated withdrawl (W) for all students earning below 60% overall grade on Thursday, October 25. A W grade and an F grade have the same effect on your full time status. The difference is that an F grade hurts your GPA, but a W grade does not. It always benefits you to get a W, instead of an F.

Disability needs: Any student who feels he or she may need an accommodation based on the impact of a disability should contact me privately to discuss his or her specific needs. Please contact Disability Services at 474-5655 to coordinate reasonable accommodations for students with documented disabilities.

Big Tip: Always come to class. Never be late. You are responsible for all material presented in class, even at times when you are absent.

Class Etiquette: Students who participate in this class in an adequate fashion have good attendance and are in the classroom at the start of the class. They stay until the end of class. They have a good record of turning in homework. They do not disturb those around them (whispering, leaving to get food, eating during class, etc). Those students that participate in a substantial fashion are attentive and discuss ideas in a reasonable and polite fashion. Please turn off all beeping devices (cell phones, watches) before the start of each class. Absolutely no cell phones or headphones are allowed in class during tests, quizzes or lectures**. If I see or hear your cell phone you will be asked to leave class for the day.**